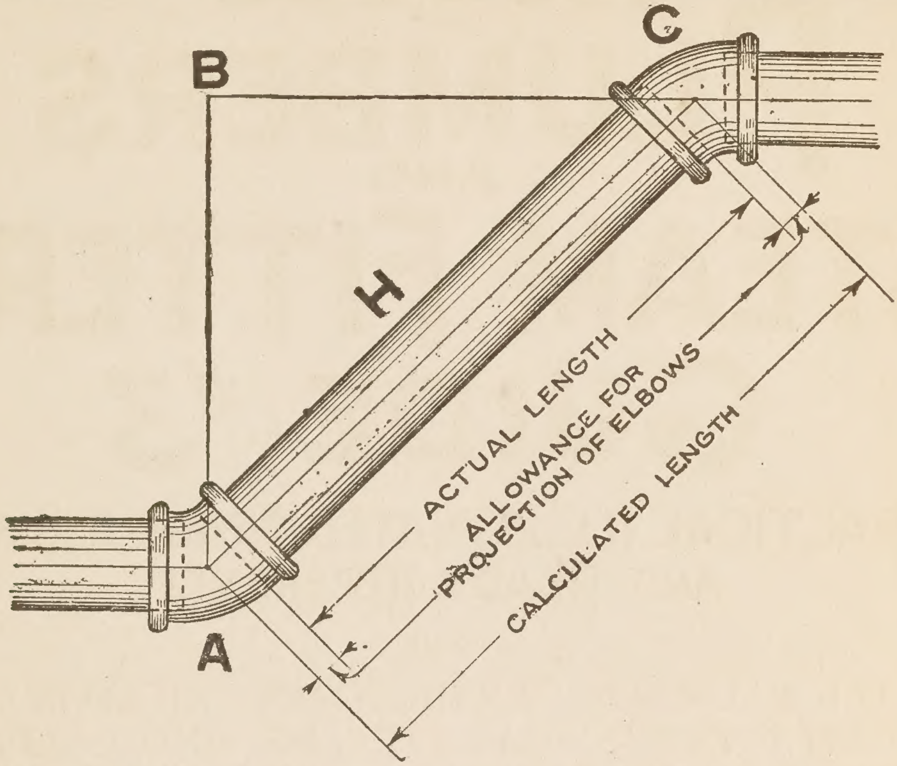
AUDELS PLUMBERS AND STEAM FITTERS GUIDE #3

CALCULATION OF OFFSETS



Calculated and actual length of connecting pipe with elbows other than 90°. Note carefully the allowances or deduction from calculated length for projections of elbows.

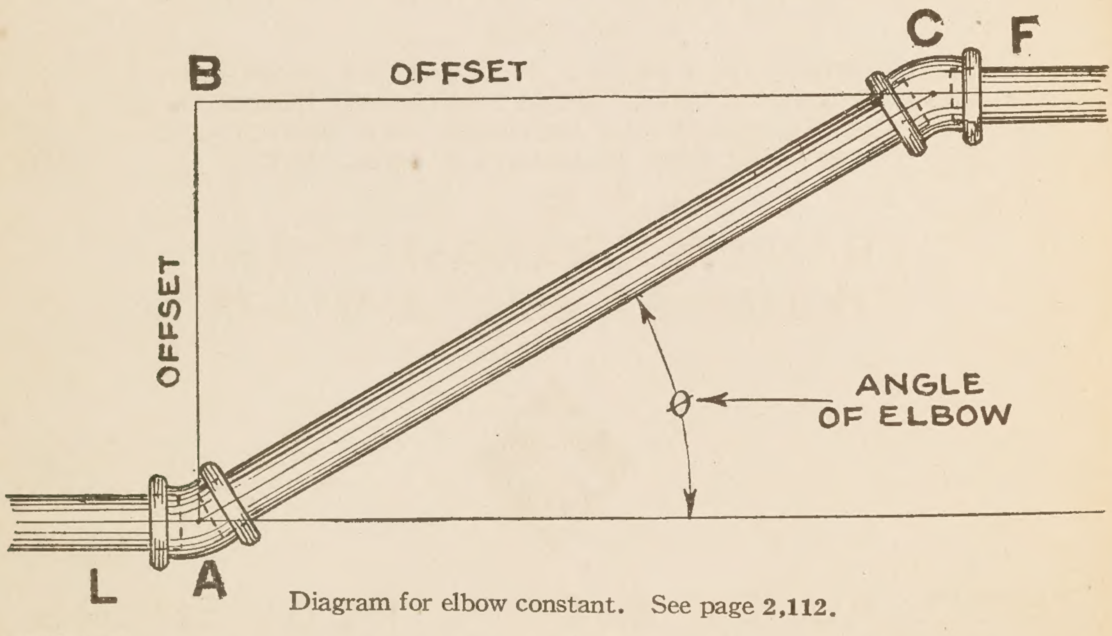


Diagram for elbow constant. See page **2,112**.

NOTE.—Methods of calculating offsets, 1, by the aid of geometry will be found on page **2,110**, and 2, by aid of trigonometry on pages **1,128** and **1,129** (in Guide No. 1).

"BY HAMMER AND HAND ALL THINGS DO STAND"

AUDELS PLUMBERS AND STEAM FITTERS GUIDE #3

A PRACTICAL ILLUSTRATED TRADE ASSISTANT AND READY REFERENCE

FOR

MASTER PLUMBERS, JOURNEYMEN AND APPRENTICES
STEAM FITTERS, GAS FITTERS AND HELPERS,
SHEET METAL WORKERS AND DRAUGHTSMEN
MASTER BUILDERS AND ENGINEERS

EXPLAINING IN PRACTICAL CONCISE LANGUAGE AND BY WELL DONE ILLUSTRATIONS, DIAGRAMS, CHARTS GRAPHS AND PICTURES THE PRINCIPLES OF MODERN PLUMBING PRACTICE

BY

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THEO. AUDEL & CO. - PUBLISHERS
65 W. 23RD ST., NEW YORK, U. S. A.

Foreword

These Guides give first hand reliable practical information in clear and concise form. They illustrate ***Plumbing*** in its many practical applications in the clearest and plainest manner and in a way not to discourage the searcher for practical plumbing knowledge, but to make an interesting, instructive and useful reference for all interested in any branch of plumbing.

In the prepartion of these Guides, the aim of the author has been to present the subject in ***the simplest possible manner,*** because no matter how well informed the reader may be, he absorbs the desired information much more readily when presented in simple, brief language, than he would when confronted with an unnecessary display of technicalities.

The aim throughout has been to simplify and give information on ***every phase of plumbing.***

Frank D. Graham.

OUTLINE OF CHAPTERS

READY REFERENCE INDEX
and
READERS' GUIDE

An hour with a book would have brought to your mind,
The secret that took the whole year to find;
The facts that you learned at enormous expense,
Were all on a library shelf to commence.

To the Reader and Student:

Read over this index occasionally and get the habit of looking for *unexpected information.* The ready reference index tells you on what pages to find the information sought for.

When you are interested and want information quickly on a problem in ***Plumbing,*** if you have the habit of consulting these ***Plumbers' Guides*** they will answer your problem.

Learn to use the index; all subjects covered are listed under their proper headings; it is also suggested to look up closely allied subjects for side lights on your problems.

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CHAPTER 120

Screwed Pipe Fittings

Since pipe cannot be obtained in unlimited lengths, and the fact that in practically all pipe installations there are numerous changes in directions, branches, etc., pipe fittings have been devised for the necessary connections. By definition the term *pipe fittings* is used to denote all those fittings that may be attached to pipes in order 1, to alter the direction of a pipe, 2, to connect a branch with a main, 3, to close an end, and 4, to connect two pipes of different sizes.*

There is an undue multiplicity of fittings on the market and the supply house that keeps all of them is indeed hard to find, hence in *pipe fitting*,† it is advisable to use only the simplest fittings, because special or unusual forms are hard to get and costly.

All these various fittings may be classed,

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*NOTE.—According to the National Tube Co., couplings and valves are not considered as fittings. Couplings are excluded perhaps on account of the custom of furnishing a coupling with each length of pipe. Strictly speaking, however, the author believes that couplings should be regarded as fittings.

†NOTE.—The difference in meaning between the terms *pipe fittings* and *pipe fitting* should be noted. Thus, *pipe fittings* denotes the various devices, such as elbows, T's, etc., used in connecting pipes, and *pipe fittings*, the process of cutting, threading, and screwing the pipes and fittings together, the man who does this being called a *pipe fitter*. There are a good many persons posing as pipe fitters who have no right to the title *judging from the quality of their work*.

1. With respect to material, as

    a. Cast iron.
    b. Malleable iron.
    c. Brass.
    d. Steel { cast / forged

2. With respect to design, as

    a. Plain.
    b. Beaded.
    c. Band

3. With respect to the method of connecting, as

    a. Screwed.
    b. Flanged.
    c. Ball and spigot.

4. With respect to strength, as

    a. Standard.
    b. Extra strong (or heavy).
    c. Double extra strong (or extra heavy).

5. With respect to the surface, as

    a. Black.
    b. Galvanized.

6. With respect to finish, as

    a. Rough.
    b. Semi-finished.
    c. Polished.

7. With respect to service, as

    a. Gas.
    b. Steam.
    c. Hydraulic (heavy pressure).
    d. Drainage.
    e. Railing.
    f. Sprinkler

8. With respect to thread, as

   a. Briggs' Standard.
   b. Recess threaded.*
   c. Fine thread.*

The following definitions (from the National Tube Co.'s book of pipe standards), relating to pipes, joints, and fittings will be found helpful to the pipe fitter, and those desiring to acquire a knowledge of the subject.

DEFINITIONS

Armstrong Joint.—A two bolt, flanged or lugged connection for high pressures. The ends of the pipes are peculiarly formed to properly hold a gutta-percha ring. It was originally made for cast iron pipe. The two bolt feature has much to commend it. There are various substitutes for this joint, many of which employ rubber in place of gutta-percha; others use more bolts in order to reduce the cost.

Bell and spigot joint.—1. The usual term for the joint in cast iron pipe. Each piece is made with an enlarged diameter or bell at one end into which the plain or spigot end of another piece is inserted when laying. The joint is then made tight by cement, oakum, lead, rubber or other suitable substance, which is driven in or caulked into the bell and around the spigot. When a similar joint is made in wrought pipe by means of a cast bell (or hub), it is at times called hub and spigot joint (poor usage). Matheson joint is a name applied to a similar joint in wrought pipe which has the bell formed from the pipe. 2. Applied to fittings or valves, means that one end of the run is a "bell" and the other end is a "spigot," similar to those used on regular cast iron pipe.

Bonnet.—1. A cover used to guide and enclose the tail end of a valve spindle. 2. A cap over the end of a pipe.

Branch.—The outlet or inlet of a fitting not in line with the run, but which may make any angle.

Branch ell.—1. Used to designate an elbow having a back outlet in line

*NOTE.—Recess threaded fittings used on Durham drainage system, and fine thread fittings used with Plumber's tubing are presented in separate chapters.

with one of the outlets of the "run." It is also called a heel outlet elbow. 2. Incorrectly used to designate side outlet or back outlet elbow.

Branch pipe.—A very general term, used to signify a pipe either cast or wrought, that is equipped with one or more branches. Such pipes are used so frequently that they have acquired common names such as tees, crosses, side or back outlet elbows, manifolds, double branch elbows, etc. The term branch pipe is generally restricted to such as do not conform to usual dimensions.

Branch tee. (header).—A tee having many side branches. (See manifold.)

Bull head tee.—A tee, the branch of which is larger than the run.

Bushing.—A pipe fitting for the purpose of connecting a pipe with a fitting of larger size, being a hollow plug with internal and external threads to suit the different diameters.

Card weight pipe.—A term used to designate standard or full weight pipe, which is the Briggs' standard thickness of pipe.

Close nipple.—One of the length of which is about twice the length of a standard pipe thread and is without any shoulder.

Coupling.—A threaded sleeve used to connect two pipes. Commercial couplings are threaded to suit the exterior thread of the pipe. The term coupling is occasionally used to mean any jointing device and may be applied to either straight or reducing sizes.

Cross.—A pipe fitting with four branches arranged in pairs, each pair on one axis, and the axis at right angles. When the outlets are otherwise arranged the fittings are branch pipes or specials.

Cross over.—A fitting with a double offset, or shaped like the letter U with the ends turned out. It is only made in small sizes and used to pass the flow of one pipe past another when the pipes are in the same plane.

Cross over tee.—A fitting made along the lines similar to cross over, but having at one end two openings in a tee head the plane of which is at right angles to the plane of the cross over bend.

Cross valve.—1. A valve fitted on a transverse pipe so as to open communication at will between two parallel lines of piping. Much used in connection with oil and water arrangements, especially on shipboard. 2. Usually considered as an angle valve with a back outlet in the same plane as the other two openings.

Crotch.—A fitting that has a general shape of the letter Y. Caution should be exercised not to confuse the crotch and wye ('Y).

Double branch elbow.—A fitting that, in a manner, looks like a tee, or as if two elbows had been shaved and then placed together, forming a shape something like the letter Y or a crotch.

Double sweep tee.—A tee made with easy curves between body and branch, that is, the center of the curve between run and branch lies outside the body.

Drop elbow.—A small sized ell that is frequently used where gas is put into a building. These fittings have wings cast on each side. The wings have small countersunk holes so that they may be fastened by wood screws to a ceiling or wall or framing timbers.

Drop tee.—One having the same peculiar wings as the drop elbow.

Dry joint.—One made without gasket or packing or smear of any kind, as a ground joint.

Elbow (*ell*).—A fitting that makes an angle between adjacent pipes. The angle is always 90 degrees, unless another angle is stated. (See Branch, Service and Union Ell.)

Extra heavy.—When applied to pipe, means pipe thicker than standard pipe; when applied to valves and fittings, indicates goods suitable for a working pressure of 250 pounds per square inch.

Header.—A large pipe into which one set of boilers is connected by suitable nozzles or tees, or similar large pipes from which a number of smaller ones lead to consuming points. Headers are often used for other purposes—for heaters or in refrigeration work. Headers are essentially branch pipes with many outlets, which are usually parallel. Largely used for tubes or water tube boilers.

Hydrostatic joint.—Used in large water mains, in which sheet lead is forced tightly into the bell of a pipe by means of the hydrostatic pressure of a liquid.

Lead joint.—1. Generally used to signify the connection between pipes which is made by pouring molten lead into the annular space between a bell and spigot, and then making the lead tight by calking. 2. Rarely used to mean the joint made by pressing the lead between adjacent pieces, as when a lead gasket is used between flanges.

Lead wool.—A material used in place of molten lead for making pipe joints. It is lead fiber, about as coarse as fine excelsior, and when made in a strand, it can be calked into the joints, making them very solid.

Line pipe.—Special brand of pipe that employs recessed and taper

thread couplings, and usually greater length of thread than Briggs' standard. The pipe is also subjected to higher test.

Lip union.—1. A special form of union characterized by the lip that prevents the gasket being squeezed into the pipe so as to obstruct the flow. 2. A ring union, unless flange is specified.

Manifold.—1. A fitting with numerous branches used to convey fluids between a large pipe and several smaller pipes. (See Branch Tee.) 2. A header for a coil.

Matheson joint.—A wrought pipe joint made by enlarging one end of the pipe to form a suitable lead recess, similar to the bell of a cast iron pipe, and which receives the male or spigot end of the next length.

Practically the same style of a joint as used for cast iron pipe.

Medium pressure.—When applied to valves and fittings, means suitable for a working pressure of from 125 to 175 pounds per sq. in.

Needle valve.—A valve provided with a long tapering point in place of the ordinary valve disc. The tapering point permits fine graduation of the opening. At times called a needle point valve.

Nipple.—1. A tubular pipe fitting usually threaded on both ends and under 12 inches in length. Pipe over 12 inches is regarded as cut pipe. (See close, short, shoulder and space nipples.)

Reducer.—1. A fitting having a larger size at one end than at the other. Some have tried to establish the term "increaser"—thinking of direction of flow—but this has been due to misunderstanding of the trade custom of always giving the largest size of run of a fitting first; hence, all fittings having more than one size are reducers. They are always threaded inside unless specified flanged or for some special joint. 2. Threaded type, made with abrupt reduction. 3. Flanged pattern with taper body. 4. Flanged eccentric pattern with taper body, but flanges at 90 degrees to one side of body. 5. Misapplied at times, to a reducing coupling.

Run.—1. A length of pipe that is made of more than one piece of pipe. 2. The portion of any fitting having its end "in line" or nearly so, in contradistinction to the branch or side opening, as of a tee. The two main openings of an ell also indicate its run, and where there is a third opening on an ell, the fitting is a "side outlet" or "back outlet" elbow, except that when all three openings are in one plane and the back outlet is in line with one of the run openings, the fitting is a "heel outlet elbow" or a "single sweep tee" or sometimes a "branch tee."

Rust joint.—Employed to secure rigid connection. The joint is made by packing the intervening space tightly with a stiff paste which oxidizes

the iron, the whole rusting together and hardening into a solid mass. It generally cannot be separated except by destroying some of the pieces. One recipe is 80 pounds cast iron borings or filings, 1 pound sal-ammoniac, 2 pounds flowers of sulphur, mixed to a paste with water.

Service ell.—An elbow having an outside thread on one end. Also known as a ***street ell.***

Service pipe.—A pipe connecting mains with a dwelling.

Service tee.—A tee having inside thread on one end and on branch, but outside thread on the other end of run. Also known as ***street tee.***

Short nipple.—One whose length is a little greater than that of two threaded lengths or somewhat longer than a close nipple. It always has some unthreaded portion between the two threads.

Shoulder nipple.—A nipple any length, which has a portion of pipe between two pipe threads. As generally used, however, it is a nipple about halfway between the length of a close nipple and a short nipple.

Space nipple.—A nipple with a portion of pipe or shoulder between the two threads. It may be of any length long enough to allow a shoulder.

Standard pressure.—A term applied to valves and fittings suitable for a working steam pressure of 125 pounds per square inch.

Street elbow.—An elbow having an outside thread on one end; also called service ell.

Tee.—A fitting, either cast or wrought, that has one side outlet at right angles to the run. A single outlet branch pipe. (See branch, bull head, cross over, double sweep, drop, service and union tees.)

Union.—1. The usual trade term for a device used to connect pipes. It commonly consists of three pieces which are first, the thread end fitted with exterior and interior threads; second, the bottom end fitted with interior threads and a smaller exterior shoulder; and third, the ring which has made an inside flange at one end while the other end has an inside thread like that on the exterior of the thread end. A gasket is placed between the thread and bottom ends, which are drawn together by the ring. Unions are very extensively used, because they permit of connections with little disturbance of the pipe positions.

Union ell.—An ell with a male or female union at one end.

Union fitting.—An elbow or tee combined with a union.

Union joint.—The pipe coupling, usually threaded, which permits disconnection without disturbing other sections.

Union tee.—A tee with male or female union at connection on one end of run.

Wiped joint.—A lead joint in which the molten solder is poured upon the desired place, after scraping and fitting the parts together, and the joint is wiped up by hand with a moleskin or cloth pad while the metal is in a plastic condition.

Wye (*y*).—A fitting either cast or wrought that has one side outlet at any angle other than 90 degrees. The angle is usually 45 degrees, unless another angle is specified. The fitting indicated by the letter Y.

Cast Iron Fittings.—Standard beaded or flat band fittings of cast iron are suitable for 125 lbs. steam or 175 lbs. water pressure. These fittings will require from 1,000 to 2,500 lbs. to burst them, the large factor of safety is necessary in their use because of the strain due to expansion, contraction, weight of piping, settling and water hammer, and quality of the work of erecting, together with the possibility that they will not run uniform. For steam pressures above 125 lbs. extra heavy fittings should be used.

Malleable Iron Fittings.—Standard beaded or flat band fittings of malleable iron are intended for steam pressures up to 150 lbs. Such fittings have at various times been subjected to hydraulic pressures of from 2,000 to 4,000 lbs. without bursting them. It would accordingly seem that they would be safe for 250 lbs. steam pressure.

If proper care be exercised in fitting and using them they will undoubtedly be found satisfactory for pressures up to 500 lbs., but as all fittings are subjected to strain due to expansion, contraction, and making up the joints, they are not recommended for pressures over 150 lbs. In fact, since extra heavy fittings cost only a little more, it is in general not economical to use standard fittings for pressures above 150 lbs.

Standard plain pattern malleable fittings are used for low pressure gas and water, house plumbing and railing work.

Brass Fittings.—These are made in both standard, extra heavy, and cast iron patterns (iron pipe sizes), and are used for brass feed water pipes where bad water makes steel pipes undesirable. The standard brass fittings are usually made in sizes ¼to 3 ins., suitable for 125 lbs. pressure; extra heavy fittings, ⅛ to 6 inches, suitable for 150 lbs. pressure; cast iron patterns in all sizes, suitable for 250 lbs.

Semi-Steel Fittings.—Extra heavy semi-steel flanged fittings as listed by Kelly & Jones and others can be had in stock sizes from 1½ to 8 ins., tested to 2,000 lbs. hydraulic pressure and are recommended for 800 lbs. pressure. These fittings are regularly furnished with male face unless otherwise ordered.

Cast Steel Fittings.—These are made extra heavy with screwed or flanged ends. The screwed fittings are listed in sizes from 3 to 6 ins. The 3 to 4½ in. sizes inclusive are tested for 1,500 lbs. hydrostatic pressure, and the 5 and 6 in. sizes, for 1,200 lbs. pressure.

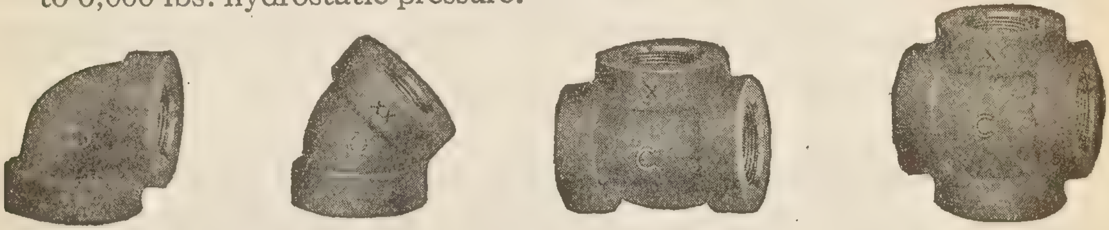
The radii of these fittings are larger than the ordinary, thereby reducing friction. They are suitable for the working pressures just given when used in hydraulic installations in which shock is absent or so slight as to be negligible.

Ordinarily these fittings, when subject to shock, should not be used for working pressures higher than 65% of the hydrostatic test pressure, and where shock is severe, 50%, or even 40%, will be more conservative. Installations of this character should always be protected by shock absorbers placed to the best advantage.

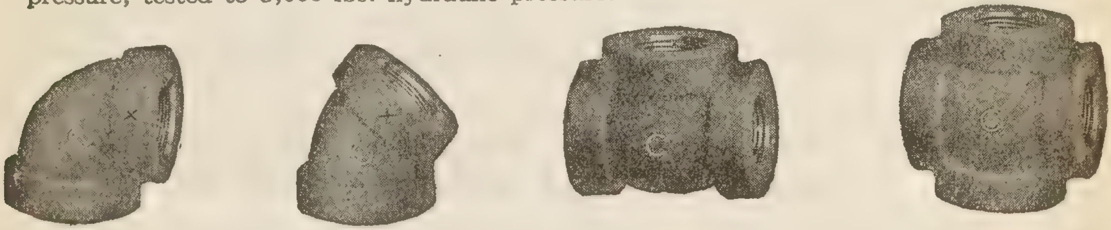
Forged Steel Fittings.—The extra heavy hydraulic forged steel screwed fittings are suitable for superheated steam up to

2,350 lbs. pressure, a total temperature of 800° Fahr., also for cold water or oil working pressures up to 3,000 lbs. hydrostatic pressure.

They are regularly made from solid forgings in sizes ranging from ½ to 2½ ins. inclusive, and are tested to 3,000 lbs. hydraulic pressure. The double extra heavy pattern is suitable for cold water or oil working pressures up to 6,000 lbs. hydrostatic pressure. They are regularly made from solid forgings in sizes ranging from ⅜ to 2 ins. inclusive, and are tested to 6,000 lbs. hydrostatic pressure.



FIGS. 7,680 to 7,683.—Crane forged steel screwed fittings made from solid forgings for superheated steam 600 lbs. pressure, 800° Fahr. or for cold water, oil or gas 3,000 lbs. hydrostatic pressure, tested to 3,000 lbs. hydraulic pressure.



FIGS. 7,684 to 7,687.—Crane forged steel screwed fittings—made from solid forgings for superheated steam 1,200 lbs. pressure, 900° Fahr. or for cold water, oil or gas 6,000 lbs. hydrostatic pressure; tested to 6,000 lbs. hydraulic pressure.

The Various Fittings.—There is a great multiplicity of fittings due to the many modifications of each *class* of fittings, and the several weights and different metals of which they are made. A list of names of these fittings may be divided into several groups, classified with respect to the use made of the fittings, as

NOTE.—***Hydrostatic and Shock Working Pressures.*** It is well known that in certain classes of hydraulic installations where quick operating valves are used, such as hydraulic forging plants, steel mill operating systems, etc., the piping is subject to more or less shock because of the sudden operation of valves. Service of this character is sometimes very severe on the valves and fittings, and though the use of properly designed shock absorbers at various points will reduce the over pressure, it is usually necessary to use heavier valves and fittings than would be required for an installation where shock is absent.

1. Extension or joining.

   a. Nipples.
   b. Lock nuts.
   c. Couplings.
   d. Offsets.
   e. Joints.
   f. Unions.

2. Reducing or enlarging.

   a. Bushings.
   b. Reducers.

3. Directional.

   a. Offsets.
   b. Elbows.
   c. Return bends.

4. Branching.

   a. Side outlet elbows.
   b. Back outlet return bends.
   c. Tees.
   d. Y branches.
   e. Crosses.

5. Shut off or closing.

   a. Plugs.
   b. Caps.
   c. Blind flanges.

6. Union or "make up."

   a. Union elbows.
   b. Union tees.

FIGS. 7,688 to 7,690.—***Close, short*** or ***shoulder,*** and ***long*** wrought nipples. ***As listed*** by Bernard Greenwood for 1-inch pipe the lengths of close, short and long nipples are 1½, 2, and 2½ to 4 inches respectively. ***Extra long*** nipples are quoted as from 13 to 24 inches, but these should be regarded as cut pipe.

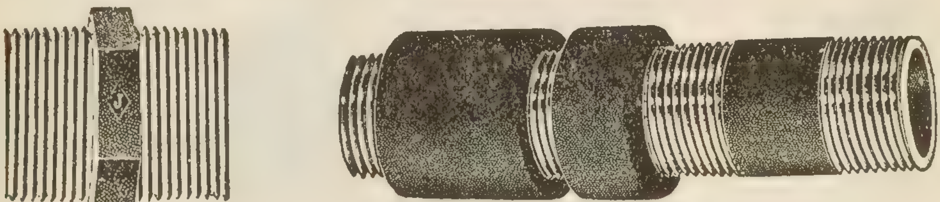
1. Extension or Joining Fittings

Nipples.—By definition a nipple is a *piece of pipe under* 12 *inches in length threaded on both ends;* pipe over 12 inches long is regarded as cut pipe. With respect to length, nipples, as shown in figs. 7,688 to 7,690 may be classed as:

1. Close;
2. Short;
3. Long;

Where fittings or valves are to be very close to each other, the intervening nipple is just long enough to take the threads at each end, being called a ***close nipple,*** as in fig. 7,688, but if a small amount of pipe intervene between the threads it is called a ***shoulder*** or ***short nipple,*** as in fig. 7,689; where a larger amount of bare pipe intervenes it is called a ***long nipple,*** as in fig. 7,690, or ***extra long nipple.*** The following table gives the standard proportion of wrought nipples:

Extra long nipples are regularly made in sizes ¾ to 1⅛×4; ¾ to 2×5; ¾ to 2½×6; ¾ to 3½×7 and 8; ¾ to 12×12, with exception of 11-inch size.



FIGS. 7,691 and 7,692.—Jarecki long screw nipple and right and left hexagon center nipple. The long screw nipple has one end of the coupling and follower faced to make a tight joint.

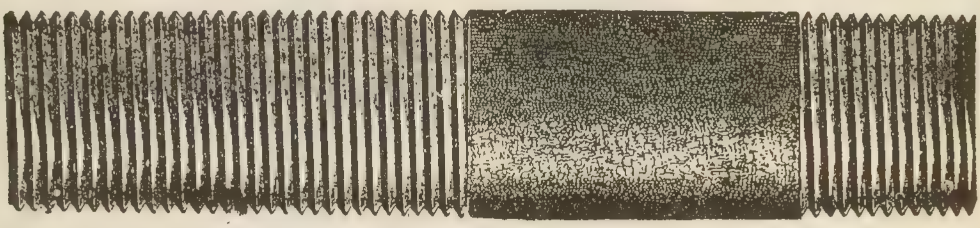


FIG. 7,693.—Tank nipple, 6 ins. long over all. Tank nipples have an American Briggs standard lock nut thread 4 ins. long on one end, and a standard pipe thread on the other end. Regularly made in sizes ¼ in. to 3 ins.

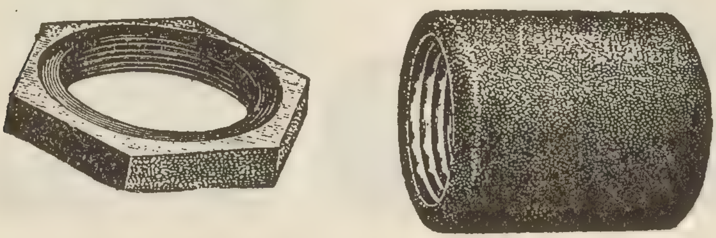
Standard Wrought Nipples

Size	⅛	¼	⅜	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	11	12
Close	¾	⅞	1	1⅛	1⅜	1½	1⅝	1¾	2	2½	2½	2¾	3	3	3¼	3¼	3½	3½	4	4	4	4
Short	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	4	4	4	4½	4½	5	5	5	5	5	5
Long	2	2	2	2	2½	2½	3	3	3	3½	3½	4½	4½	4½	5	5	6	6	8	8		8
Long	2½	2½	2½	2½	3	3	3½	3½	3½	4	4	5	5	5	5½	5½						
Long	3½	3½	3½	3½	4	4	4½	4½	4½	5	5	6	6	6	6½	6½						

Nipples having a ***right*** thread at one end and a ***left*** thread at the other are generally used in steam heating piping instead of unions. Fig. 7,691 shows a R and L (right and left thread) nipple with a hexagon nut at the center and forming part of the nipple.

Another variety is the ***long screw nipple*** shown in fig. 7,692. This has a long thread on one end on which is a coupling and lock nut, the jamb surface of the coupling and lock nut being faced; the combination forms virtually a union with male and female ends.

Fig. 7,693 shows a ***tank nipple.*** It has at one end an American Briggs, standard lock nut thread 4 ins. long, and at the other, a standard pipe thread. A heavy lock nut is used on the long thread end.



FIGS. 7,694 and 7,695.—Lock nut and coupling.

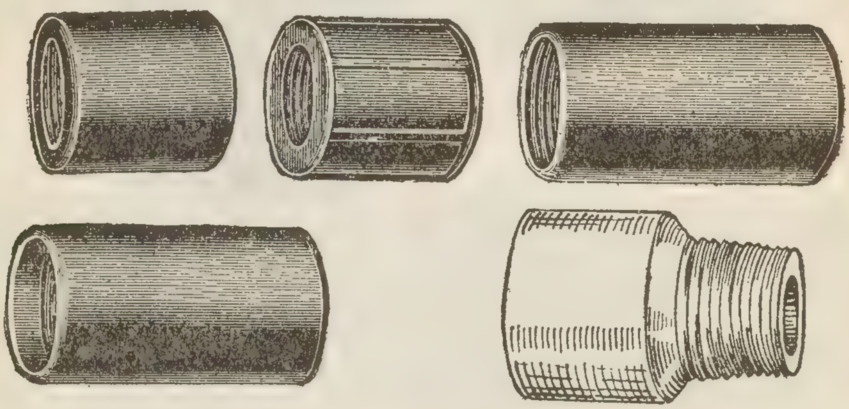
Lock Nuts.—These are made with faced end for use on long screw nipples having couplings, and with a recessed or grooved end to hold packing where this is depended upon to make a tight joint.

The use of lock nipples should be avoided wherever possible, as the joint is not so good as that obtained by a union.

Couplings.—The ordinary coupling usually comes with the pipe, one coupling to each length of pipe, and is therefore classed by some as a part of the pipe rather than a fitting. These are made of wrought or cast metal and of brass; they are regularly threaded right hand, but can be obtained with R and L thread. R and L couplings have projecting bars or rings to distinguish them from couplings with right thread only. Figs. 7,696 to 7,799 show four kinds of couplings. Another form called an *extension*

piece is shown in fig. 7,700; it differs from the standard coupling in that it has a male thread at one end. There are numerous other types, some being known as *reducers* and others as *joints.*

Joints.—There are on the market a number of special couplings or *joints* such as ammonia, Armstrong, bull, bell and spigot, block, bumped, butted and strapped, Converse, lock, corrugated, crossed artesian, cup, cup and ball, dresser, drive pipe, dry, Eckert, expanded, expansion, Field, flanged, flexible, flush, ground, hydrostatic, inserted, Kimberly, knock off, lead,



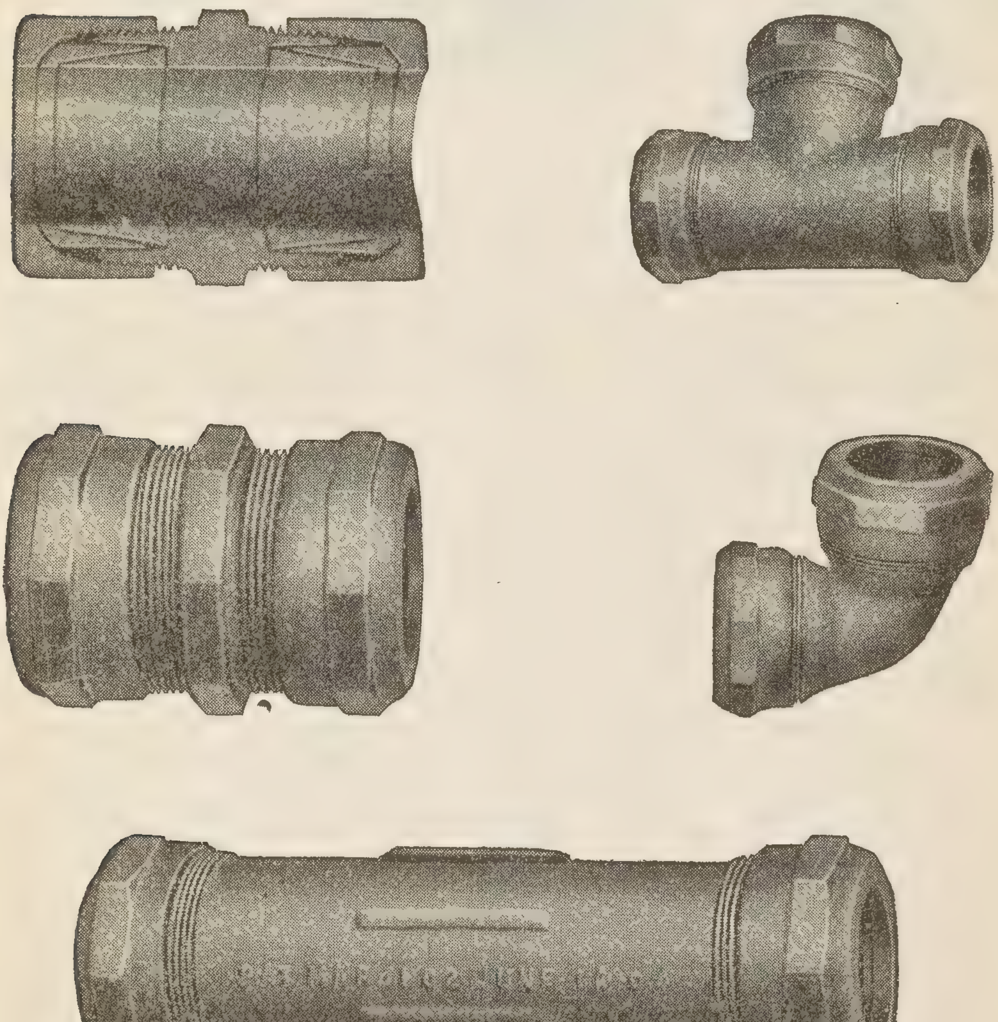
FIGS. 7,696 to 7,700.—Various couplings. Fig. 7,696, standard wrought couplings; fig. 7,697, malleable R and L (right and left) coupling; fig. 7,698, hydraulic coupling; fig. 7,699, sleeve coupling. Notice length of hydraulic and sleeve couplings as compared to the standard R and L. In fig. 7,699 the projecting sleeve is seen which covers the exposed threads beyond the joint; fig. 7,700, extension piece or coupling with male and female threads.

lead and rubber, line pipe, Matheson, National, Normandy, peeved flanged, Perkins, Petit's Pope, pressure, Riedler, rust,

NOTE.—*Standard malleable steam fittings* are suitable to stand a working pressure of 150 lbs. At various times and places they have been tested to a hydraulic pressure of 2,000 to 4,000 lbs. without breakage. It would seem that fittings which stand this test would be perfectly safe to stand 250 lbs. working pressure. If proper care is exercised in using them they will undoubtedly answer every purpose for pressures up to 500 lbs. but as these as well as other fittings are subject to some risk of straining due to expansion, contraction or the making up of joints, manufacturers do not deem it proper to recommend them for the working pressure. As goods made especially for extra heavy pressure are so very cheap, it does not seem to be a good business policy to use common fittings for such work.

shrink, Siemens, slip, socket, spigot, swing, swivel, thimble, Van Stone, Walker, welded flange and wiped joint.

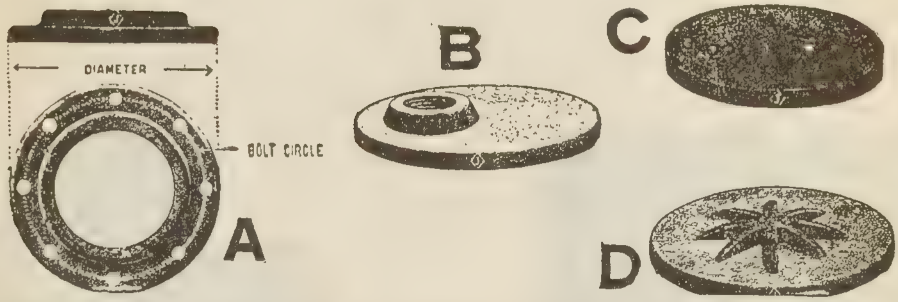
A number of these are described in the definitions, and particulars of the others may be obtained from the National Tube Co. book of standards.



FIGS 7,701 to 7,705.—Simmons grip pipe fittings for connecting pipe without threading, intended to save labor in making up pipe lines, and as they comprise numerous unions the pipe may be disconnected with little trouble.

Dimensions of Standard Flanges

American Standards for 125 lbs. Working Pressure
In effect January 1st, 1915



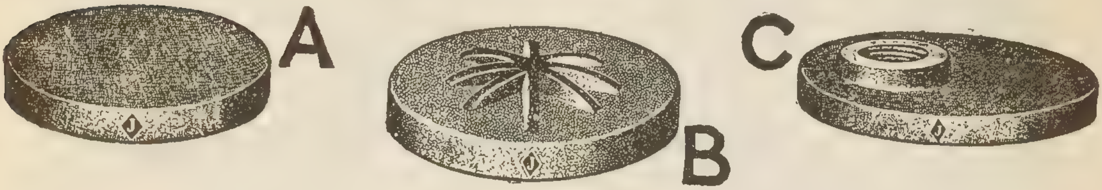
FIGS. 7,706 to 7,709.—Jarecki cast iron standard flanges. Fig. 7,706, common; fig. 7,707, eccentric; fig. 7,708, solid 16 in. *o.d.* and smaller; fig. 7,709, solid 19 in. *o.d.* and smaller.

Pipe Size Inches.	Outside Diameter of Flanges Inches.	Thickness of Flanges Inches.	Thickness Through Boss Inches.	Bolt Circle Inches.	Number of Bolts.	Size of Bolts Inches.
1	4	7/16	11/16	3	4	7/16x1½
1¼	4½	½	¾	3⅜	4	7/16x1½
1½	5	9/16	⅞	3⅞	4	½x1¾
2	6	⅝	1	4¾	4	⅝x2
2½	7	11/16	1 1/16	5½	4	⅝x2¼
3	7½	¾	1⅛	6	4	⅝x2½
3½	8½	13/16	1 3/16	7	4	⅝x2½
4	9	15/16	1 3/16	7½	8	⅝x2¾
4½	9¼	15/16	1¼	7¾	8	¾x3
5	10	15/16	1 5/16	8½	8	¾x3
6	11	1	1 7/16	9½	8	¾x3
7	12½	1 1/16	1½	10¾	8	¾x3
8	13½	1⅛	1⅝	11¾	8	¾x3¼
9	15	1⅛	1¾	13¼	12	¾x3¼
10	16	1 3/16	1⅞	14¼	12	⅞x3½
12	19	1¼	2 1/16	17	12	⅞x3¾
14	21	1⅜	2 3/16	18¾	12	1 x4¼
15	22¼	1⅜	2 3/16	20	16	1 x4¼
16	23½	1 7/16	2 5/16	21¼	16	1 x4¼
18	25	1 9/16	2 7/16	22¾	16	1⅛x4¾
20	27½	1 11/16	2⅝	25	20	1⅛x5
22	29½	1 13/16	2¾	27¼	20	1¼x5½
24	32	1⅞	2⅞	29½	20	1¼x5½

Bolt holes are drilled ⅛-inch larger than nominal diameter of bolts

Dimensions of Extra Heavy Flanges

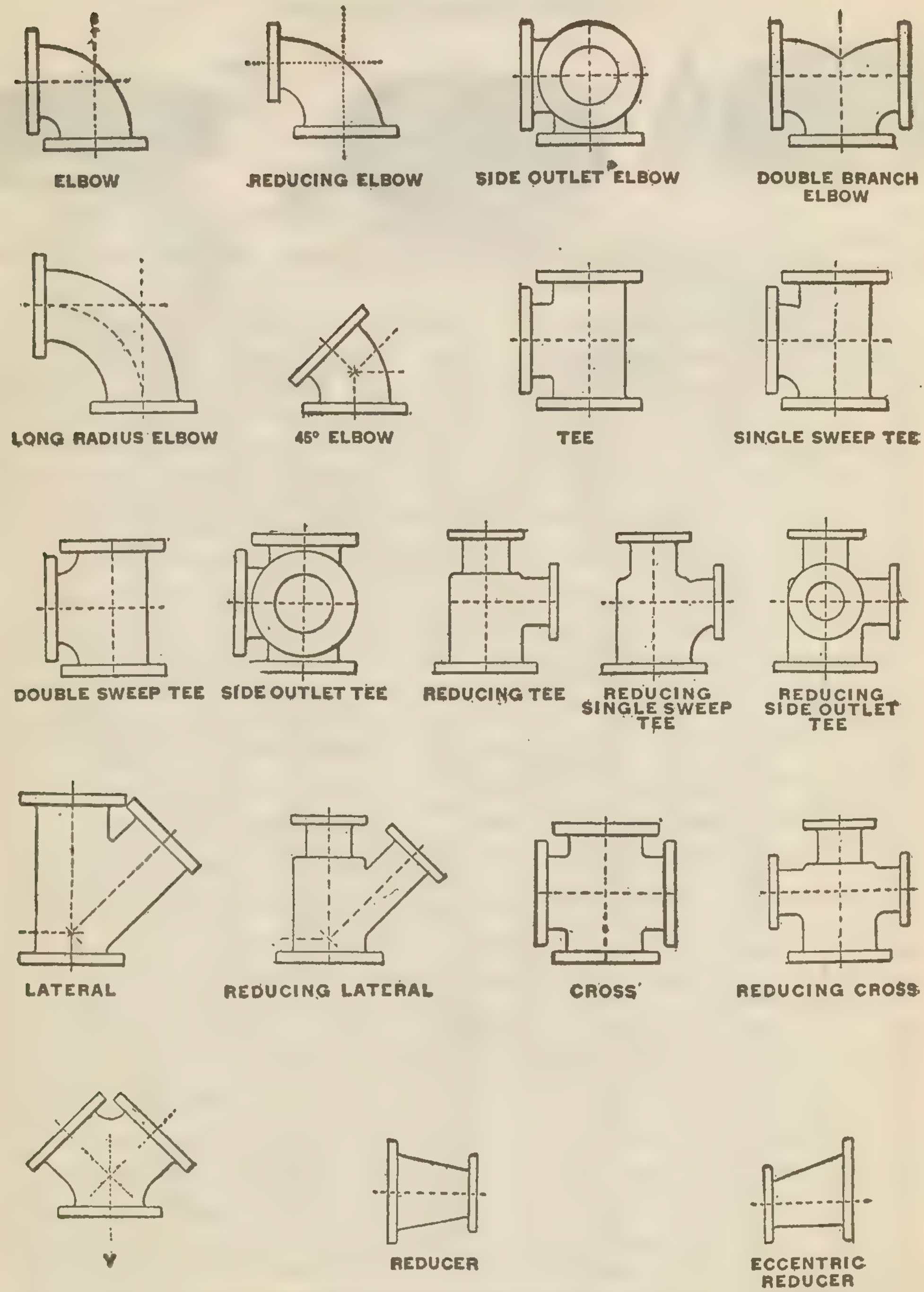
American Standard for 250 lbs. Working Pressure
In effect January 1st, 1915



FIGS. 7,710 to 7,712.—Jarecki cast iron extra heavy flanges. **A**, solid 16 in. and smaller, plain face; **B**, solid 18 in. and larger, **C**, eccentric plain face.

PIPE SIZE. Inches.	Diameter of Flanges.	Thickness of Flanges.	Bolt Circle.	Number of Bolts.	Size of Bolts.	Length of Bolts.
1	4½	11/16	3¼	4	½	2
1¼	5	¾	3¾	4	½	2¼
1½	6	13/16	4½	4	⅝	2½
2	6½	⅞	5	4	⅝	2½
2½	7½	1	5⅞	4	¾	3
3	8¼	1⅛	6⅝	8	¾	3
3½	9	1 3/16	7¼	8	¾	3¼
4	10	1¼	7⅞	8	¾	3½
4½	10½	1 5/16	8½	8	¾	3½
5	11	1⅜	9¼	8	¾	3¾
6	12½	1 7/16	10⅝	12	¾	3¾
7	14	1½	11⅞	12	⅞	4
8	15	1⅝	13	12	⅞	4¼
9	16¼	1¾	14	12	1	4½
10	17½	1⅞	15¼	16	1	4¾
12	20½	2	17¾	16	1⅛	5
14	23	2⅛	20¼	20	1⅛	5¼
15	24½	2 3/16	21½	20	1¼	5½
16	25½	2¼	22½	20	1¼	5¾
18	28	2⅜	24¾	24	1¼	6
20	30½	2½	27	24	1⅜	6½
22	33	2⅝	29¼	24	1½	6¾
24	36	2¾	32	24	1⅝	7

Bolt holes are drilled ⅛-inch larger than nominal diameter of bolts.



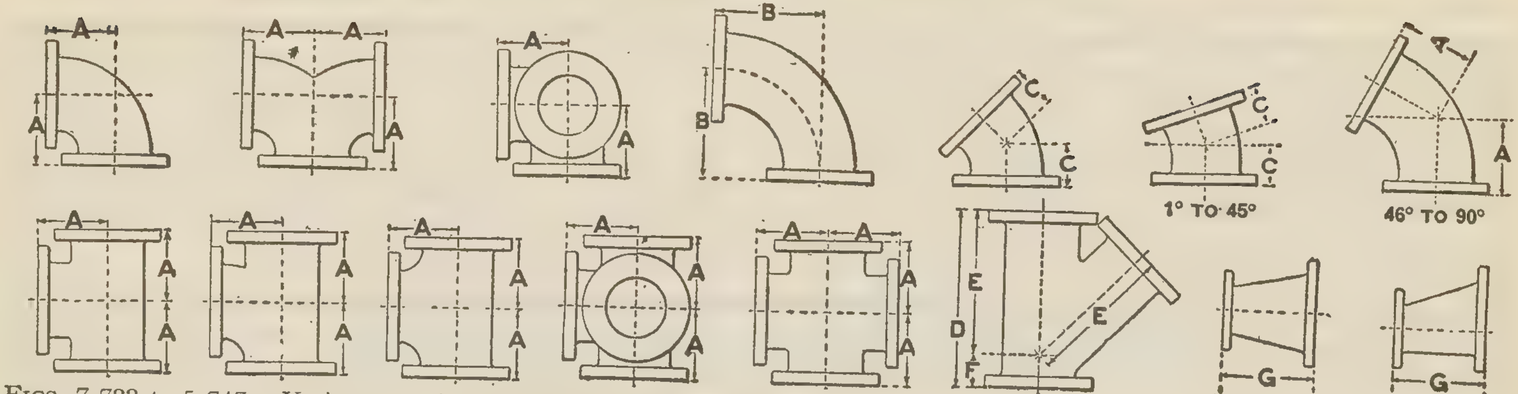
FIGS. 7,713 to 7,732.—American standard names of flanged fittings.

AMERICAN STANDARD

STANDARD AND LOW PRESSURE FLANGED FITTINGS

CAST IRON

GENERAL DIMENSIONS OF STRAIGHT SIZES



FIGS. 7,733 to 7,747.—Various cast iron flange fittings; straight sizes.

Size.....Inches	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20
Size.....Millimeters	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375	400	450	500
AA—Face to Face, Tees and Crosses. Inches	7	7½	8	9	10	11	12	13	14	15	16	17	18	20	22	24	28	29	30	33	36
*A—C. to F., Elbows, Tees and Crosses Inches	3½	3¾	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	11	12	14	14½	15	16½	18
B—C. to F., Long Radius Elbows....Inches	5	5½	6	6½	7	7¾	8½	9	9½	10¼	11½	12¾	14	15¼	16½	19	21½	22¾	24	26½	29
*C—Center to Face, 45° Elbows....Inches	1¾	2	2¼	2½	3	3	3½	4	4	4½	5	5½	5½	6	6½	7½	7½	8	8	8½	9½
D—Face to Face, 45° Laterals......Inches	7½	8	9	10½	12	13	14½	15	15½	17	18	20½	22	24	25½	30	33	34½	36½	39	43
E—Center to Face, 45° Laterals.....Inches	5¾	6¼	7	8	9½	10	11½	12	12½	13½	14½	16½	17½	19½	20½	24½	27	28½	30	32	35
F—Center to Face, 45° Laterals.....Inches	1¾	1¾	2	2½	2½	3	3	3	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8
G—Face to Face, Reducers.........Inches						6	6½	7	7½	8	9	10	11	11½	12	14	16	17	18	19	20
Diameter of Flanges................Inches	4	4½	5	6	7	7½	8½	9	9¼	10	11	12½	13½	15	16	19	21	22¼	23½	25	27½
Thickness of Flanges...............Inches	7/16	½	9/16	⅝	11/16	¾	13/16	15/16	15/16	15/16	1	1 1/16	1⅛	1⅛	1 3/16	1¼	1⅜	1⅜	1 7/16	1 9/16	1 11/16

*Special Angle Fittings 1° to 45° use center to face dimension of 45° Elbow, and 46° to 90° use center to face dimension of 90° Elbow

AMERICAN STANDARD

STANDARD AND LOW PRESSURE FLANGED FITTINGS

CAST IRON

GENERAL DIMENSIONS OF STRAIGHT SIZES

CONTINUED

Size.....In.	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62
Size.....Millimeters	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550
AA—Face to Face, Tees and Crosses..In.	40	44	46	48	50	52	54	56	58	60	62	64	66	68	70	74	78	82	84	88	90
*A—C. to F., Elbows, Tees and Crosses.In.	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	37	39	41	42	44	45
B—C. to F., Long Radius Elbows.....In.	31½	34	36½	39	41½	44	46½	49	51½	54	56½	59	61½	64	66½	69	71½	74	76½	79	81½
*C—Center to Face, 45° Elbows.....In.	10	11	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
D—F. to F., 45° Laterals...In.	46	49½	53	56	59																
E—C. to F., 45° Laterals...In.	37½	40½	44	46½	49																
F—C. to F., 45° Laterals...In.	8½	9	9	9½	10																
G—Face to Face, Reducers.In.	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62
Diameter of Flanges.....In.	29½	32	34¼	36½	38¾	41¾	43¾	46	48¾	50¾	53	55¼	57¼	59½	61¾	64	66¼	68¾	71	73	75¾
Thickness of Flanges.....In.	1 13/16	1⅞	2	2 1/16	2⅛	2¼	2 5/16	2⅜	2⅜	2½	2⅝	2⅝	2 11/16	2¾	2¾	2⅞	3	3	3⅛	3⅛	3¼

Size.....In.	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
Size.....Millimeters	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500
AA—Face to Face, Tees and Crosses..In.	94	96	100	102	106	108	112	116	118	120	124	126	130	134	136	138	142	146	148
*A—C. to F., Elbows, Tees and Crosses.In.	47	48	50	51	53	54	56	58	59	60	62	63	65	67	68	69	71	73	74
B—C. to F., Long Radius Elbows.....In.	84	86½	89	91½	94	96½	99	101¼	104	106½	109	111½	114	116½	119	121½	124	126½	129
*C—Center to Face, 45° Elbows.....In.	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
G—Face to Face, Reducers.In.	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
Diameter of Flanges.....In.	78	80	82¼	84½	86½	88½	90¾	93	95¼	97½	99¾	102	104¼	106½	108¾	111	113¼	115½	117¾
Thickness of Flanges.....In.	3¼	3⅜	3⅜	3½	3½	3⅝	3⅝	3¾	3¾	3⅞	3⅞	4	4	4⅛	4⅛	4¼	4¼	4⅜	4⅜

*Special Angle Fittings 1° to 45° use center to face dimension of 45° Elbow, and 46° to 90° use center to face dimension of 90° Elbow.

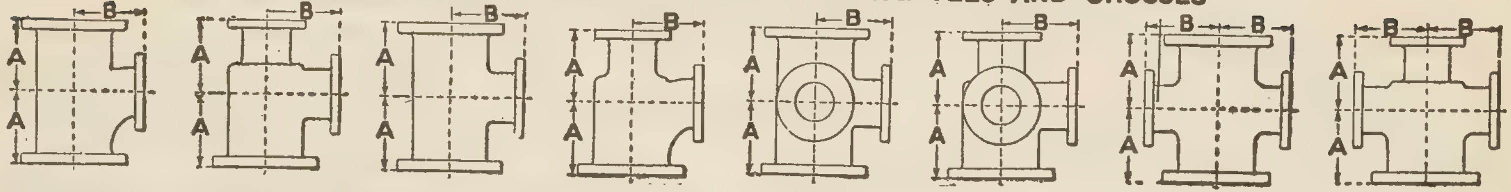
Standard and Low Pressure Flanged Fittings are furnished plain faced unless otherwise ordered.

AMERICAN STANDARD

STANDARD AND LOW PRESSURE FLANGED FITTINGS

CAST IRON

GENERAL DIMENSIONS OF REDUCING TEES AND CROSSES



FIGS. 7,748 to 7,755.—Various reducing cast iron tees and crosses; short body pattern.

SHORT BODY PATTERN

Size..........Inches	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30	32	34	36	38	40
Size......Millimeters	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600	650	700	750	800	850	900	950	1000
*Size Out. & Smlr Ins.	All reducing fittings 1-inch to 16-inch, inclusive, have the same center to face dimensions as straight size fittings.																			12	14	15	16	18	18	20	20	22	24	24	26
Size Out. & Sm. Millm.																				300	350	375	400	450	450	500	500	550	600	600	650
AA—F. to F., Run Ins.																				26	28	28	30	32	32	36	36	38	40	40	44
A—C. to F., Run Ins																				13	14	14	15	16	16	18	18	19	20	20	22
B—C. to F., Outlet Ins.																				15½	17	18	19	20	21	23	24	25	26	28	29

Size.......Inches	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
Size...Millimeters	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500
Size of Out. & Sm. In.	28	28	30	32	32	34	36	36	38	40	40	42	44	44	46	48	48	50	52	52	54	56	56	58	60	60	62	64	64	66
Size of O. & S. Mill.	700	700	750	800	800	850	900	900	950	1000	1000	1050	1100	1100	1150	1200	1200	1250	1300	1300	1350	1400	1400	1450	1500	1500	1550	1600	1600	1650
AA-F. to F.. Run. In.	46	46	48	52	52	54	58	58	62	66	66	68	70	70	74	80	80	84	86	86	88	94	94	96	100	100	104	106	106	110
A-C to F. Run. In.	23	23	24	26	26	27	29	29	31	33	33	34	35	35	37	40	40	42	43	43	44	47	47	48	50	50	52	53	53	55
B-C. to F, Out In.	30	31	33	34	35	36	37	39	40	41	42	44	45	46	47	48	49	50	52	53	54	56	57	58	61	62	63	64	65	67

***LONG BODY PATTERNS** Are used when outlets are larger than given in the above table, therefore have same dimensions as straight size fittings.

The dimensions of "Reducing Flanged Fittings" are always regulated by the reduction of the outlet.

FITTINGS REDUCING ON THE RUN ONLY, the long body pattern will always be used, **EXCEPT DOUBLE SWEEP TEES,** on which the reduced end is always longer than the regular fittings. Dimensions on request.

BULL HEADS OR TEES having outlets larger than the run, will be the same length center to face of all openings as a Tee with all openings of the size of the outlet. For example a 12 x 12 x 18-inch Tee will be governed by the dimensions of the 18-inch Long Body Tee, namely, 16½ inches center to face of all openings and 33 inches face to face.

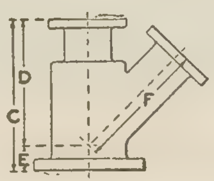
REDUCING ELBOWS carry same center to face dimension as regular elbows of largest straight size.

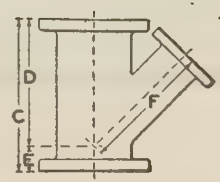
AMERICAN STANDARD

STANDARD AND LOW PRESSURE FLANGED FITTINGS

CAST IRON

GENERAL DIMENSIONS OF REDUCING 45° LATERALS





FIGS. 7,756 and 7,757.—Cast iron reducing 45° laterals; short body pattern.

SHORT BODY PATTERN

Size . . . Inches	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30
Size . . . Millimeters	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600	650	700	750
*Size of Branch and Smaller . . . Inches																				9	10	10	12	12	14	15
Size . . . Millimeters																				225	250	250	300	300	350	375
C—Face to Face, Run . . . Inches	All reducing fittings 1 to 16-inch, inclusive, have same center to face dimensions as straight size fittings.																			26	28	29	32	35	37	39
D—Center to Face, Run . . . Inches																				25	27	28½	31½	35	37	39
E—Center to Face, Run . . . Inches																				1	1	½	½	0	0	0
F—Center to Face, Branch . . . Inches																				27½	29½	31¾	34½	38	40	42

***LONG BODY PATTERNS** Are used when branches are larger than given in the above table, therefore have same dimensions as straight size fittings.

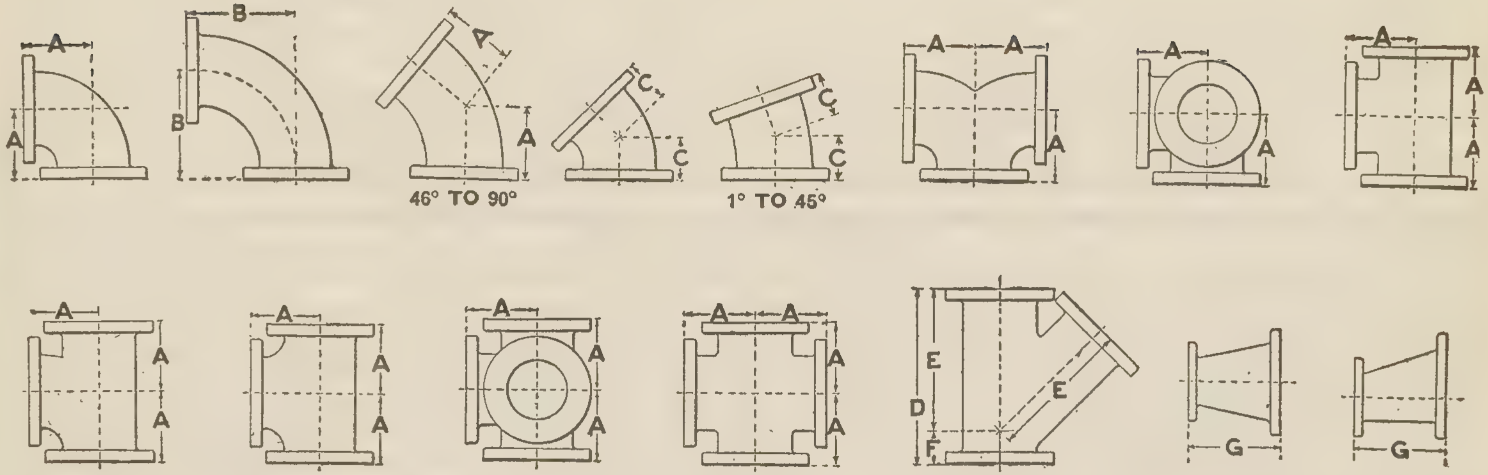
The dimensions of Reducing Flanged Fittings are always regulated by the reduction of the branch; fittings reducing on the run only, the long body pattern will always be used.

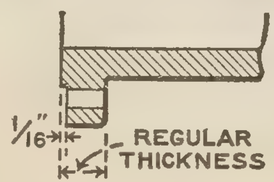
AMERICAN STANDARD

EXTRA HEAVY FLANGED FITTINGS

CAST IRON, FERROSTEEL AND CAST STEEL

GENERAL DIMENSIONS OF STRAIGHT SIZES





NOTE—All extra heavy flanges have a 1/16-inch Raised Face inside of bolt holes. This Raised Face is included in face to face, center to face and thickness of flange dimensions.

Figs. 7,758 to 7,773.—Various cast iron ferrosteel and cast steel extra heavy flange fittings; heavy sizes.

AMERICAN STANDARD

EXTRA HEAVY FLANGED FITTINGS

CAST IRON, FERROSTEEL AND CAST STEEL

GENERAL DIMENSIONS OF STRAIGHT SIZES

Size.....In.	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
Size.....Millimeters	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375
AA–Face to Face, Tees and Crosses In.	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	31
*A–Center to Face, Elbows, Tees and Crosses. In.	4	4¼	4½	5	5½	6	6½	7	7½	8	8½	9	10	10½	11½	13	15	15½
B–Center to Face, Long Radius Elbows.....In.	5	5½	6	6½	7	7¾	8½	9	9½	10¼	11½	12¾	14	15¼	16½	19	21½	22¾
*C–Center to Face, 45° Elbows.....In.	2	2½	2¾	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9
D–Face to Face, 45° Laterals.....In.	8½	9½	11	11½	13	14	15½	16½	18	18½	21½	23½	25½	27½	29½	33½	37½	39½
E–Center to Face, 45° Laterals.....In.	6½	7¼	8½	9	10½	11	12½	13½	14½	15	17½	19	20½	22½	24	27½	31	33
F–Center to Face, 45° Laterals.....In.	2	2¼	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5	5½	6	6½	6½
G–Face to Face, Reducers.....In.						6	6½	7	7½	8	9	10	11	11½	12	14	16	17
Diameter of Flanges.....In.	4½	5	6	6½	7½	8¼	9	10	10½	11	12½	14	15	16¼	17½	20½	23	24½
Thickness of Flanges.....In.	11/16	¾	13/16	⅞	1	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½	1⅝	1¾	1⅞	2	2⅛	2 3/16
Size.....In.	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	
Size.....Millimeters	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	
AA–Face to Face, Tees and Crosses In.	33	36	39	41	45	48	52	55	58	61	65	68	71	74	78	81	84	
*A–Center to Face, Elbows, Tees and Crosses. In.	16½	18	19½	20½	22½	24	26	27½	29	30½	32½	34	35½	37	39	40½	42	
B–Center to Face, Long Radius Elbows.....In.	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54	56½	59	61½	64	
*C–Center to Face, 45° Elbows.....In.	9½	10	10½	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
D–Face to Face, 45° Laterals.....In.	42	45½	49	53	57½													
E–Center to Face, 45° Laterals.....In.	34½	37½	40½	43½	47½													
F–Center to Face, 45° Laterals.....In.	7½	8	8½	9½	10													
G–Face to Face, Reducers.....In.	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	
Diameter of Flanges.....In.	25½	28	30½	33	36	38¼	40¾	43	45¼	47½	50	52¼	54½	57	59¼	61½	65	
Thickness of Flanges.....In.	2¼	2⅜	2½	2⅝	2¾	2 13/16	2 15/16	3	3⅛	3¼	3⅜	3 7/16	3 9/16	3 11/16	3¾	3⅞	4	

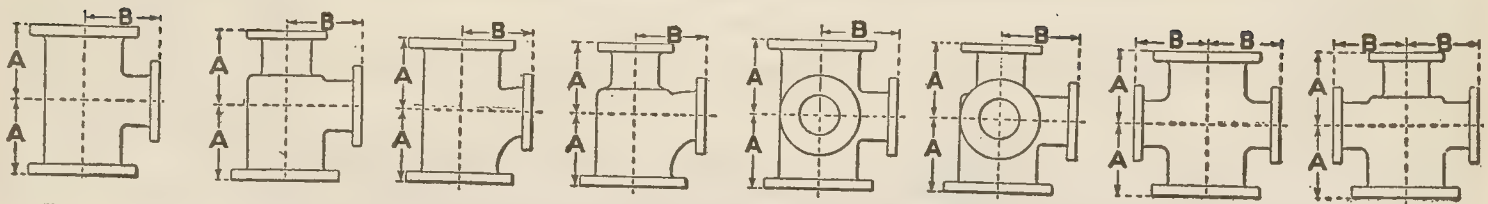
***SPECIAL ANGLE FITTINGS** 1° to 45° use center to face dimension of 45° Elbow, and 46° to 90° use center to face dimension of 90° Elbow.

AMERICAN STANDARD

EXTRA HEAVY FLANGED FITTINGS

CAST IRON, FERROSTEEL AND CAST STEEL

GENERAL DIMENSIONS REDUCING TEES AND CROSSES



FIGS. 7,774 to 7,781.—Various cast iron ferrosteel and cast steel extra heavy flange reducing tees and crosses; short body pattern.

SHORT BODY PATTERN

All reducing fittings 1-inch to 16-inch, inclusive, have the same center to face dimensions as straight size fittings.

Size......Inches	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
Size......Millimeters	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
*Size of Outlet and Smaller......Inches	12	14	16	16	18	18	20	20	22	24	24	26	28	28	30	32
*Size of Outlet and Smaller......Millimeters	300	350	375	400	450	450	500	500	550	600	600	650	700	700	750	800
AA—Face to Face, Run......Inches	28	31	33	34	38	38	41	41	44	47	47	50	53	53	55	58
A—Center to Face, Run......Inches	14	15½	16½	17	19	19	20½	20½	22	23½	23½	25	26½	26½	27½	29
B—Center to Face, Outlet......Inches	17	18½	20	21½	23	24	25½	26½	28	29½	30½	31½	33½	34½	35½	37½

***LONG BODY PATTERNS** {Are used when outlets are larger than given in the above table, therefore have same dimensions as straight size fittings.

The dimensions of "Reducing Flanged Fittings" are always regulated by the reduction of the outlet.

FITTINGS REDUCING ON THE RUN ONLY, the long body pattern will always be used, except double sweep tees, on which the reduced end is always longer than the regular fitting. Dimensions on request.

BULL HEADS OR TEES having outlets larger than the run, will be the same length center to face of all openings as a Tee with all openings of the size of the outlet. For example, a 12x12x18-inch Tee will be governed by the dimensions of the 18-inch Long Body Tee, namely, 18 inches center to face of all openings and 36 inches face to face.

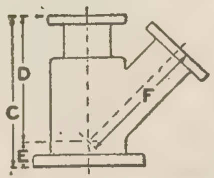
REDUCING ELBOWS carry same center to face dimension as regular elbows of largest straight size.

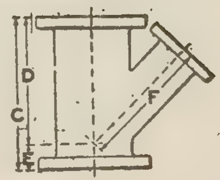
AMERICAN STANDARD

EXTRA HEAVY FLANGED FITTINGS

CAST IRON, FERROSTEEL AND CAST STEEL

GENERAL DIMENSIONS OF REDUCING 45° LATERALS





FIGS. 7,782 and 7,783.—Cast iron ferrosteel and cast steel reducing 45° Lateral; short body pattern.

SHORT BODY PATTERN

Size.................Inches	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
Size.............Millimeters	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600
*Size of Branch & Smaller..Inches	All reducing fittings 1 to 16-inch, inclusive, have same center to face dimensions as straight size fittings.																			9	10	10	12
*Size of Br. & Smaller.Millimeters																				225	250	250	300
C-Face to Face, Run .....Inches																				34	37	40	44
D-Center to Face, Run ...Inches																				31	34	37	41
E-Center to Face, Run. ..Inches																				3	3	3	3
F-Center to Face, Branch Inches																				32½	36	39	43

***LONG BODY PATTERNS**—Are used when branches are larger than given in the above table, therefore have same dimensions as straight size fittings.

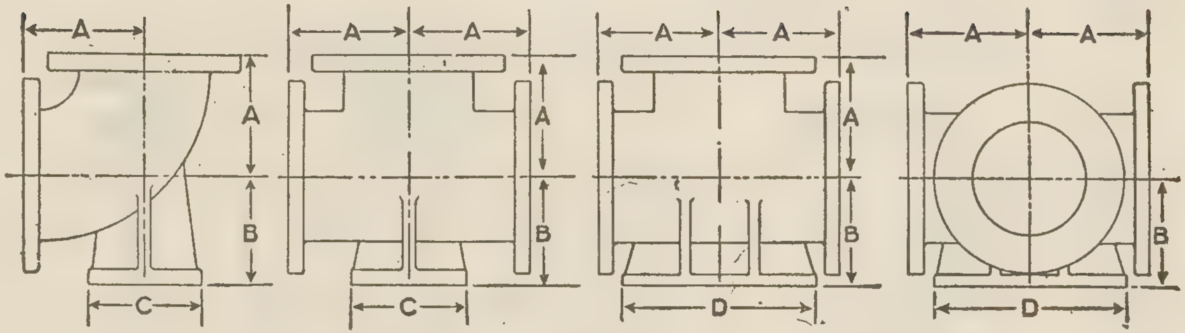
The dimensions of Reducing Flanged Fittings are always regulated by the reduction of the branch; fittings reducing on the run only, the long body pattern will always be used.

LOW PRESSURE AND STANDARD

BASE AND ANCHORAGE FITTINGS

CAST IRON

GENERAL DIMENSIONS



FIGS. 7,784 to 7,787.—Various cast iron base and anchorage fittings.

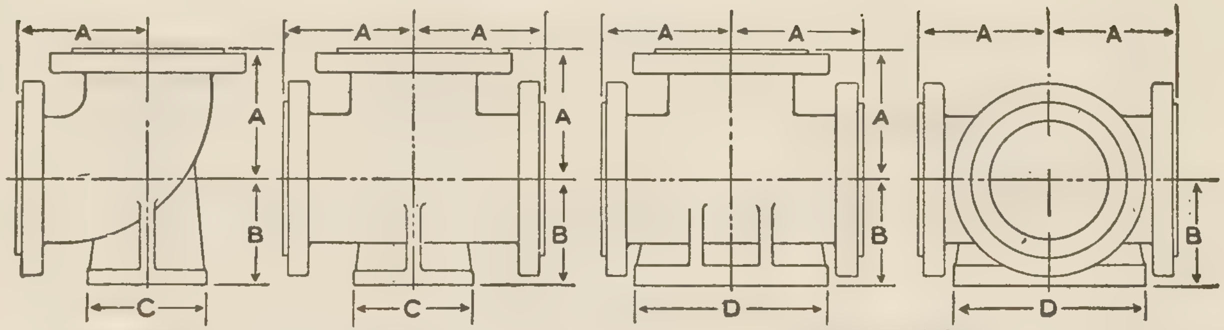
Size .... Inches	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
Size .... Millimeters	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600
A—Center to Face, Ells and Tees .... Inches	6½	7	7½	8	8½	9	10	11	12	14	14½	15	16½	18	20	22
B—Center to Face, Base Flange .... Inches	6½	6¾	7	7½	8¼	8¾	9½	10	10½	13½	14	14¾	15½	16¾	17¾	18¾
C—Base Flange—Across Flats of Square or Diam. of Round.. Inches	6	6	7	7	7	9	9	9	11	11	11	11	13½	13½	13½	13½
D—Anchorage Flange, Across Flats of Square .... Inches	9	9¼	10	11	12½	13½	15	16	19	21	22¼	23½	25	27½	29½	32
Size of Pipe Support for Round Base Flange .... Inches	2	2	2½	2½	2½	[illegible]	4	4	6	6	6	6	8	8	8	8

EXTRA HEAVY

BASE AND ANCHORAGE FITTINGS

CAST IRON, FERROSTEEL AND CAST STEEL

GENERAL DIMENSIONS



FIGS. 7,788 to 7,791.—Various cast iron ferrosteel and cast steel base and anchorage fittings.

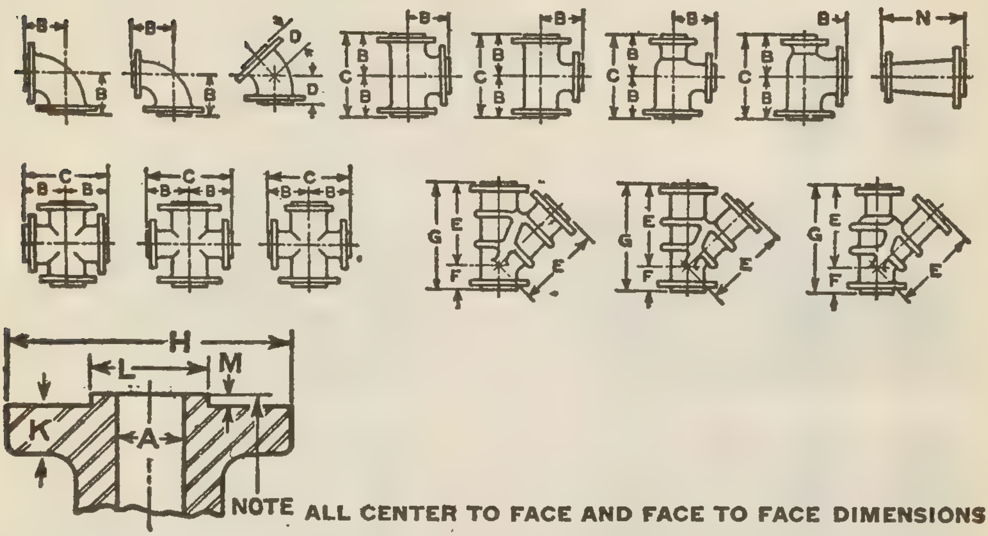
Size.....Inches	4	4½	5	6	7	8	9	10	12	14	15	16
Size.....Millimeters	100	113	125	150	175	200	225	250	300	350	375	400
A—Center to Face, Ells and Tees.....Inches	7	7½	8	8½	9	10	10½	11½	13	15	15½	16½
B—Center to Face, Base Flange.....Inches	7	7¼	7½	8	8¾	9¼	10	10½	11	14	14½	15¼
C—Base Flange—Across Flats of Square or Diameter of Round...Inches	6½	6½	7½	7½	7½	10	10	10	12½	12½	12½	12½
D—Anchorage Base, Across Flats of Square.....Inches	10	10½	11	12½	14	15	16	17	19	22½	23½	25
Size of Pipe Support for Round Base.....Inches	2	2	2½	2½	2½	4	4	4	6	6	6	6

800 POUND

AMERICAN HYDRAULIC STANDARD

FERROSTEEL

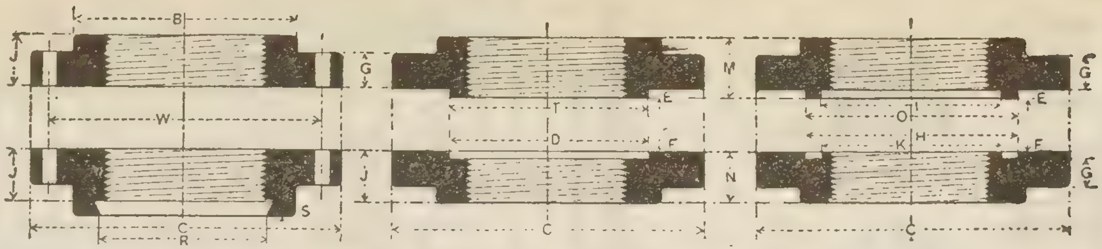
GENERAL DIMENSIONS



FIGS. 7,792 to 7,806.—Various hydraulic Ferrosteel fittings.

Size Inches	Size Milli-meters	Inside Dia. at Port A	Center to face El-bows Tee Cross B	Center to face 45° El-bow D	Center to face Lat-eral E	Center to face Lat-eral F	Dia. of Flange H	Thick-ness of Flange K	Dia. of Raised Face L	Height of Raised Face M	Face to Face Taper Re-ducers N
½	13	½	3¼	2	5½	1¾	3½	9/16	1⅜	¼	4½
¾	19	¾	3¾	2¼	6	2	4	⅝	1 11/16	¼	4½
1	25	1	4¼	2¼	6¾	2¼	4½	11/16	2	¼	4½
1¼	32	1¼	4½	2¾	7½	2½	5	¾	2¼	¼	4½
1½	38	1½	4¾	3	8¾	2¾	6	13/16	2⅞	¼	4½
2	50	2	5¾	4¼	11	3½	6¾	1¼	3⅝	¼	5
2½	64	2½	6½	4½	12½	3½	7½	1⅜	4⅛	¼	5½
3	76	3	7	5	13½	4	8½	1½	5	¼	6
3½	90	3½	7½	5½	14½	4½	9½	1⅝	5½	¼	6½
4	100	4	8½	6	16½	4½	10¾	1⅞	6 3/16	¼	7
4½	113	4½	9	6½	17½	5½	11½	2	6¾	¼	7½
5	125	5	10	7	19½	6	13	2⅛	7 5/16	¼	8
6	150	6	11	7½	21	6½	14	2¼	8½	¼	9
7	175	7	12	8	22½	6½	15	2⅜	9⅝	¼	10
8	200	8	13	8½	24½	7	16½	2½	10⅝	¼	11
9	225	9	14½	9	27½	7½	18½	2¾	11⅝	¼	11½
10	250	10	15½	9½	29½	8	20	2⅞	12¾	¼	12
12	300	12	16½	10	31½	8½	22	3	15	¼	14

EXTRA HEAVY CAST IRON FLANGES



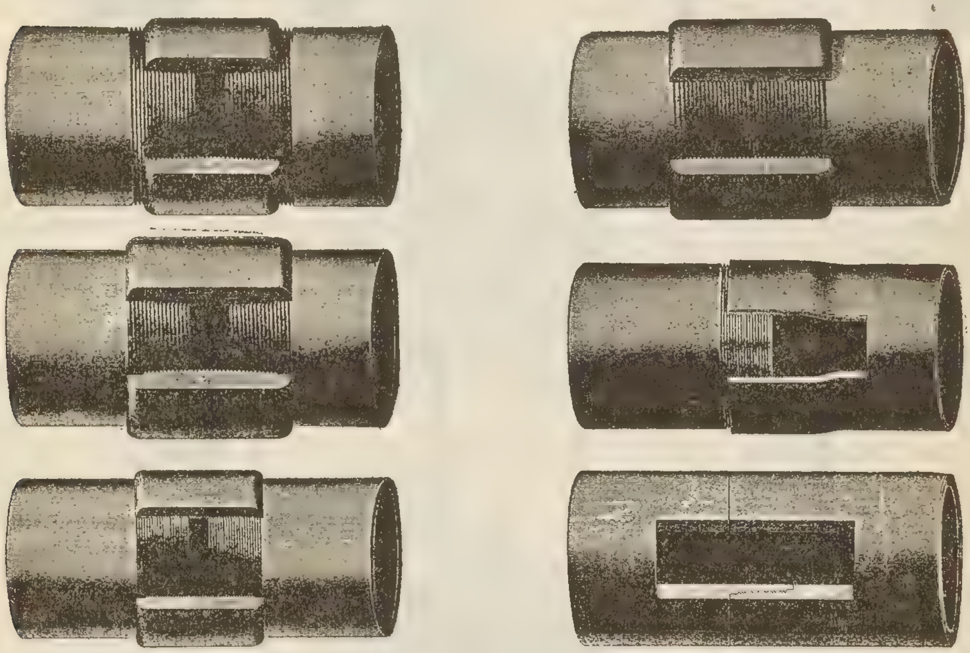
FIGS. 7,807 to 7,809.—Various extra heavy cast iron flanges. Fig. 7,807, plain straight faces; fig. 7,808, male and female faces; fig. 7,809, tongue and groove faces.

TABLE OF DIMENSIONS

Size,	Inches	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6	7	8	9	10	12	14	15	16	18	20	22	24
B—Hub Diameter	Inches	2 1/16	2 1/2	2 7/8	3 5/16	4	4 5/8	5 1/4	5 3/4	6 3/16	6 3/4	7 15/16	9	10 1/8	11 1/16	12 3/8	14 5/8	15 7/8	16 15/16	18	20 1/8	22 5/16	24 1/2	26 3/4
C—Diameter of Flange	Inches	4 1/2	5	6	6 1/2	7 1/2	8 1/4	9	10	10 1/2	11	12 1/2	14	15	16 1/4	17 1/2	20 1/2	23	24 1/2	25 1/2	28	30 1/2	33	36
G—Thickness of Flange	Inches	11/16	3/4	13/16	7/8	1	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 3/16	2 1/4	2 3/8	2 1/2	2 5/8	2 3/4
J—Thickness through Boss	Inches	1	1 1/8	1 1/4	1 3/8	1 7/16	1 9/16	1 5/8	1 3/4	1 11/16	1 7/8	2	2 1/16	2 3/16	2 1/4	2 3/8	2 9/16	2 11/16	2 13/16	2 7/8	3 1/16	3 1/4	3 7/16	3 5/8
W—Diameter of Bolt Circle	Inches	3 1/4	3 3/4	4 1/2	5	5 7/8	6 5/8	7 1/4	7 7/8	8 1/2	9 1/4	10 5/8	11 7/8	13	14	16 1/4	17 3/4	20 1/4	21 1/2	22 1/2	24 3/4	27	29 1/4	32
Number of Bolts		4	4	4	4	4	8	8	8	8	8	12	12	12	12	16	16	20	20	20	24	24	24	24
Size of Bolts	Inches	1/2	1/2	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	3/4	7/8	7/8	1	1	1 1/8	1 1/8	1 1/4	1 1/4	1 1/4	1 3/8	1 1/2	1 5/8
Length of Bolts	Inches	2	2 1/4	2 1/2	2 1/2	3	3 1/4	3 1/4	3 1/2	3 1/2	3 3/4	3 3/4	4	4 1/4	4 3/4	5	5 1/2	5 3/4	6	6	6 1/4	6 3/4	7	7 1/2
Diameter of Bolt Holes	Inches	5/8	5/8	3/4	3/4	7/8	7/8	7/8	7/8	7/8	7/8	7/8	1	1	1 1/8	1 1/8	1 1/4	1 1/4	1 3/8	1 3/8	1 3/8	1 1/2	1 5/8	1 3/4
I—Inside Diameter of Tongue	Inches	1 3/4	2 1/8	2 3/4	3 1/8	3 5/8	4 1/4	4 3/4	5 1/4	5 3/4	6 1/4	7 1/2	8 5/8	9 5/8	10 5/8	11 5/8	13 5/8	15 7/8	17 1/8	18 3/8	20 3/8	22 5/16	24 1/2	26 1/2
O—Outside Diameter of Tongue	Inches	2 1/2	3	3 5/8	4 1/8	4 5/8	5 1/4	5 3/4	6 1/4	6 3/4	7 1/4	8 1/2	9 5/8	10 7/8	11 7/8	13 1/8	15 1/8	17 3/8	18 5/8	20 1/8	22 3/8	24 5/16	26 1/2	28 1/2
E—Height of Tongue (Male)	Inches	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
K—Inside Diameter of Groove	Inches	1 11/16	2 1/16	2 11/16	3 1/16	3 9/16	4 3/16	4 11/16	5 3/16	5 11/16	6 3/16	7 7/16	8 9/16	9 9/16	10 9/16	11 9/16	13 9/16	15 13/16	17 1/16	18 5/16	20 5/16	22 1/4	24 7/16	26 7/16
H—Outside Diameter of Groove	Inches	2 9/16	3 1/16	3 11/16	4 3/16	4 11/16	5 5/16	5 13/16	6 5/16	6 13/16	7 5/16	8 9/16	9 11/16	10 15/16	11 15/16	13 3/16	15 3/16	17 7/16	18 11/16	20 3/16	22 7/16	24 3/8	26 9/16	28 9/16
F—Depth of Groove (Female)	Inches	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
T—Diameter of Tongue (Male)	Inches	2 5/16	2 3/4	3 1/8	3 5/8	4 1/8	5	5 1/2	6	6 1/2	7 1/4	8 3/8	9 3/8	10 5/8	11 5/8	12 3/4	15 1/4	16 1/2	17 1/2	18 1/2	21	23	25 1/2	27 1/2
D—Diameter of Recess (Female)	Inches	2 3/8	2 13/16	3 3/16	3 11/16	4 3/16	5 1/16	5 9/16	6 1/16	6 9/16	7 5/16	8 7/16	9 7/16	10 11/16	11 11/16	12 13/16	15 5/16	16 9/16	17 9/16	18 9/16	21 1/16	23 1/16	25 9/16	27 9/16
R—Diameter of Calking Recess	Inches				2 7/8	3 3/8	4	4 1/2	5	5 1/2	6 1/16	7 1/8	8 1/8	9 1/8	10 1/8	11 1/4	13 1/4	14 1/2	15 1/2	16 1/2	18 1/2	20 1/2	22 1/2	24 1/2
S—Depth of Calking Recess	Inches				1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Width of Calking Recess— At top, Inches					1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
Width of Calking Recess— At bottom, Inches					5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
M—Height of Flange without Recess (Male)	Inches				1 9/16	1 5/8	1 3/4	1 13/16	1 15/16	2	2 1/16	2 3/16	2 5/16	2 7/16	2 1/2	2 5/8	2 13/16	2 15/16	3 1/16	3 1/8	3 5/16	3 1/2		
N—Height of Flange, without Recess (Female)	Inches				1 1/2	1 9/16	1 11/16	1 3/4	1 7/8	1 15/16	2	2 1/8	2 1/4	2 3/8	2 7/16	2 9/16	2 3/4	2 7/8	3	3 1/16	3 1/4	3 7/16		—

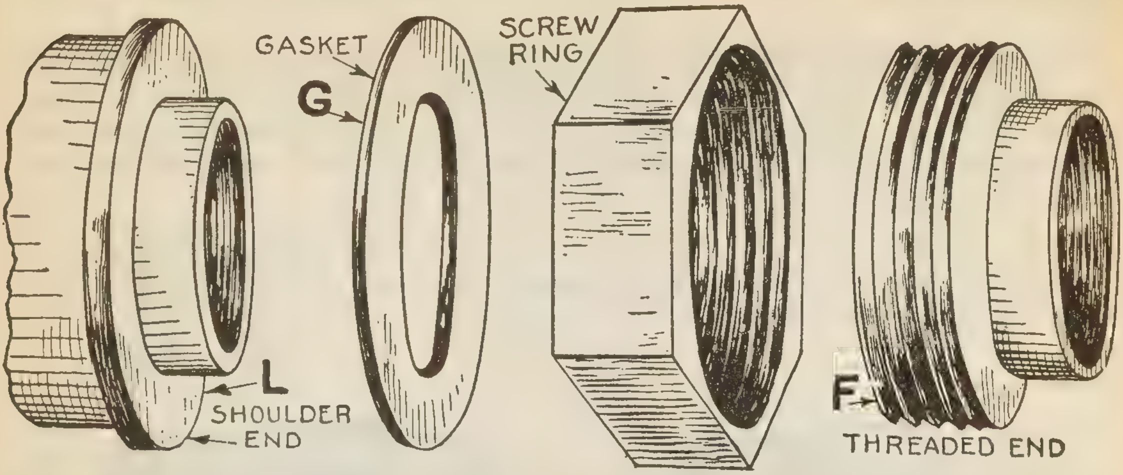
The most important of these are the screw or threaded joint (already described), and the flanged joint. Figs. 7,810 to 7,815 show various screwed joints. The accompanying tables give dimensions necessary for drilling templates of flanged valves, flanged fittings and flanges for standard and extra heavy pressures.

Figs. 7,807 to 7,809 show three kinds of flanges; plain, recessed and tongue and groove. The latter is intended for a caulking ring of soft metal to be placed in the groove.

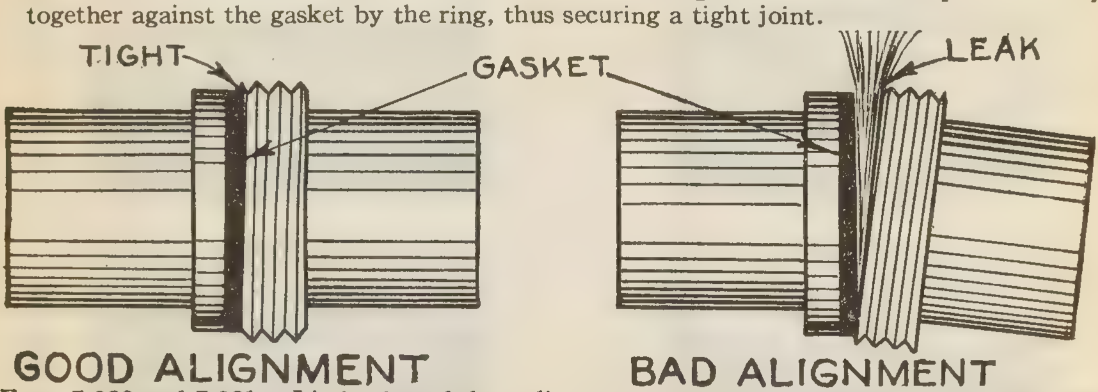


FIGS. 7,810 to 7,815.—Various screwed joints. Fig. 7,810, standard pipe joint; fig. 7,811, line pipe joint; fig. 7,812, casing joint; fig. 7,813, drive pipe joint; fig. 7,814, inserted joint casing; fig. 7,815, flush joint tubing.

Unions.—The definition (page **1,955**) plainly describes the construction of an ordinary union. There are various kinds of unions. The plain union, as shown in figs. 7,816 to 7,819, requires a gasket and incidentally the two pipes to be joined by the union must be in pretty good alignment to secure a tight joint, because of the flat surfaces which must press against the gasket. This limitation is shown in figs. 7,820 and 7,821.



FIGS. 7,816 to 7,819.—Ordinary malleable union disassembled to show parts. ***It consists of*** three parts and a gasket, as shown. ***In assembling,*** the gasket G, is placed over the projection on the shoulder so that it is in contact with surface L. The ring is slipped over the shoulder end and the threaded end placed in position so that the flat end surface F, presses against the gasket and then the ring is screwed firmly into the threaded end. Since the shoulder on the shoulder end cannot back off the ring, the two ends are pressed firmly together against the gasket by the ring, thus securing a tight joint.



FIGS. 7,820 and 7,821.—Limitation of the ordinary gasket union. *The alignment must be good to secure a tight joint.* In the figure the ring is omitted for clearness. If both ends be in line and firmly pressed together against the gasket by the ring, the gasket will bear evenly over the entire contact surfaces and the joint will be tight. If the two ends be out of alignment when the ring is screwed tight it will bring great pressure on the gasket at M, whereas the surfaces will not come together at the opposite point S, thus causing a leak.

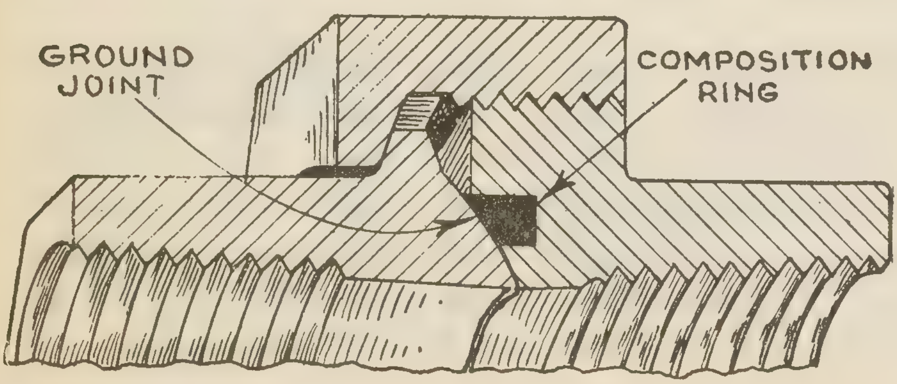


FIG. 7,822.—Jefferson brass to iron ground joint; sectional view, showing construction of joint. The composition ring is forced into the groove under great hydraulic pressure and becomes virtually a part of the grooved end.

To avoid this difficulty and also the inconvenience of the gasket, various unions have been devised, having spherical seats and ground joints. The latter, in some, consists of a composition ring bearing against iron, and in others both contact surfaces are composition. Fig. 7,823 shows the construction of the first mentioned joint and fig. 7,824 a flanged union with spherical ground joint. The joint of the union in fig. 7,823 has spherical contact and the illustration shows the tight joint secured by the form of a contact, even though the pipes be out of line. Unions are also made entirely of brass with ground joints.

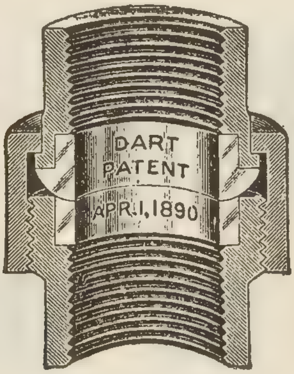


FIG. 7,823.—Dart double composition seat spherical ground joint, female union, illustrating composition to composition contact.

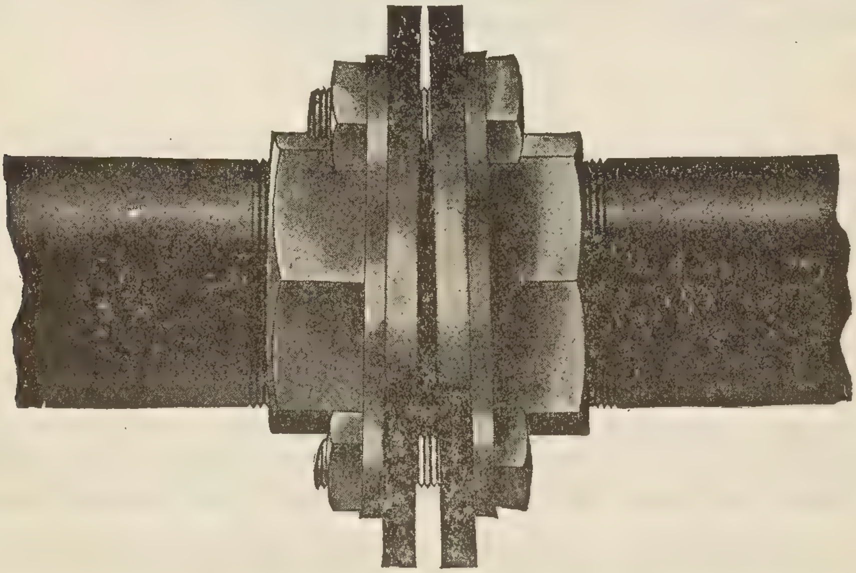


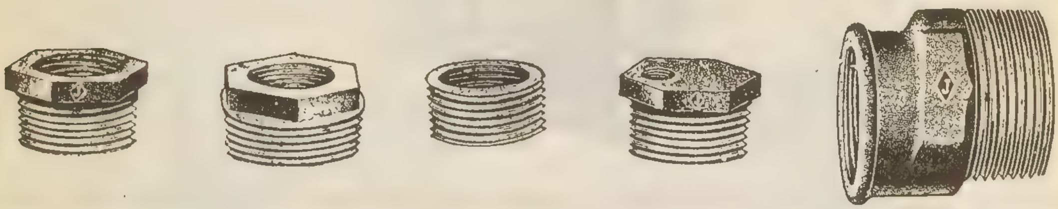
FIG. 7,824.—Jefferson flange, brass to iron, ground joint female union, illustrating the *range* of the spherical ground seat in obtaining a tight joint with pipes out of alignment.

2. Reducing or Enlarging Fittings

Bushings.—These fittings are often confused with reducers. The function of a bushing is *to connect the male end of a pipe to a fitting of larger size.* It consists of a hollow plug with male and female threads to suit the different diameters.

A bushing may be regarded as either a reducing or an enlarging fitting.

As generally manufactured, bushings 2½ inches and smaller reducing one size are malleable iron; reducing two or more sizes are cast iron, all above 2½ inches are cast iron except brass bushings, which may be obtained in sizes from ¼ to 4 inches.



FIGS. 7,825 to 7,829.—Various Jarecki bushings. Fig. 7,825, plain heavy nut bushing reducing one size; fig. 7,826, plain hexagon nut bushing, reducing more than one size; fig. 7,827, faced bushing, fig. 7,828, eccentric bushing, reducing two or more sizes; fig. 7,829, offset bushing.

Bushings are listed by the *pipe size of the **male** thread*, thus a "¼ bushing" joins a ¼ fitting to a ⅛ pipe. It is better however, in ordering, to avoid mistakes to specify both threads, calling for instance, the bushing just mentioned a ¼×⅛ bushing.

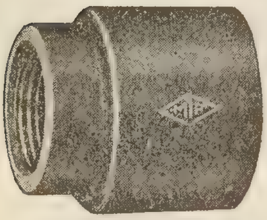
The regular pattern bushing has a hexagon nut at the female end for screwing the bushing into the fitting.

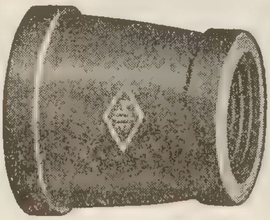
For very close work, the *faced* bushing is used, having in place of the hexagon nut a faced end. This may be used with a long screw pipe and faced lock nut to form a tight joint or to receive a male end fitting for close work. Figs. 7,826 and 7,827 show the plain and faced types of bushing.

A form valuable where drainage of the pipe line is desired, is the eccentric bushing shown in fig. 7,828. Another form is the offset bushing shown in fig. 7,829.

Reducers.—The term reducer originated from the trade custom of always giving the larger size of a run of a fitting first, and as applied, it means a reducing or enlarging coupling having female threads at both ends, as distinguished from a bushing which has both male and female threads.

Figs. 7,830 to 7,832 show various types of reducer. These are to be had in a great variety of stock sizes.





FIGS. 7,830 to 7,832.—Various M. I. F. reducers. Fig. 7,830, plain reducer for gas or low pressure fig. 7,831, flat band or reinforced reducer for steam; fig. 7,832, eccentric reducer.

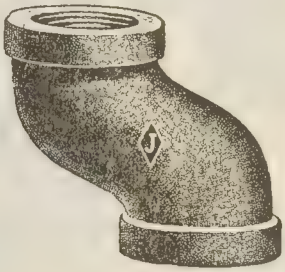


FIG. 7,833.—Jarecki standard cast iron offset. Regular sizes ¾ to 6 inches, to offset, 4, 6, or 8 inches.

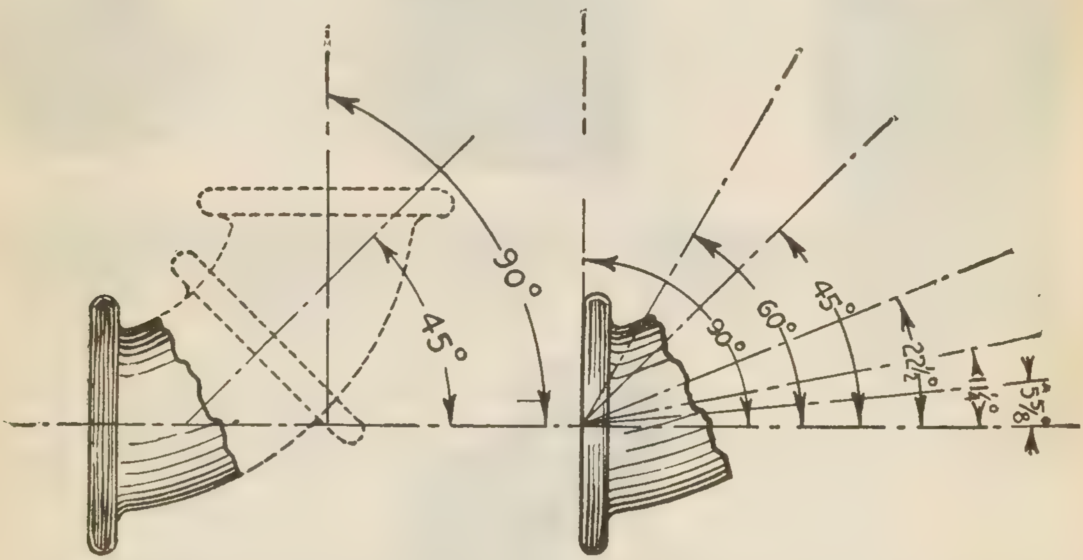
3. Directional Fittings

Offsets.—In piping, sometimes part of the pipe line must be in a position parallel to, but not in alignment with the balance of the pipe. An experienced pipe fitter can offset the line by bending the pipe, but ordinarily where the offset or distance between the two pipe axes is of standard dimension, a fitting

called an offset, as shown in fig. 7,833, can be more conveniently used.

Elbows.—Where it is necessary to change the direction of a pipe line in any of several standard and special angles, elbows are used. For gas, water and steam, the standard angles are 45° and 90° and the special angles are 22½° and 60°.

Cast iron drainage fitting elbows are regularly made with angles of 5⅝°, 11¼°, 22½°, 45°, 60°, 90°.



FIGS. 7,834 and 7,835.—Standard elbow angles. Fig. 7,834, standard for gas, water and steam; fig. 7,835, standard for drainage fittings. ***For steam,*** special angles, such as 22½° and 60°, although they can be regularly obtained from most supply houses, are best avoided where possible.

Elbow angles measure the degree that the direction is changed, as shown in figs. 7,834 and 7,835; these figures should be carefully noted to avoid confusion. The angle is ***not*** *the angle between the two arms but the angle between the axis of one arm and the* ***projected*** *axis of the other arm*, as in figs. 7,834 and 7,835.

There is a large variety of elbows. Figs. 7,836 to 7,848 show some standard patterns; figs. 7,849 and 7,850, R and L, and reducing cast iron elbows; figs. 7,851 to 7,858, various cast iron drainage elbows.

NOTE.—In addition to bushings and reducers, there are other reducers or enlarging fittings as reducing elbows, tees (so called) etc., which are later described.

FIGS. 7,836 to 7,848.—Kelly and Jones malleable iron elbows. Fig. 7,836, plain 90° elbow, fig. 7,837, flat band 90° elbow; fig. 7,838, plain 45° elbow; fig. 7,839, flat band 45° elbow; fig. 7,840, plain 60° elbow; fig. 7,841, flat band 60° elbow; fig. 7,842, 90° street elbow; fig. 7,843, 45° street elbow; fig. 7,844, female drop; fig. 7,845, drop elbow, flange right side; fig. 7,846, drop elbow, flange left side; fig. 7,847, male and female drop elbow, short pattern; fig. 7,848, male and female drop elbow long, with drop 2½ ins. long.

NOTE.—To avoid making fittings to order, the use of bushings is recommended. Where it is absolutely necessary to have special fittings made, without the use of bushings, they can be had by sending specifications to the manufacturers. The price of same in any event will be very high.

Return Bends.—These are largely used for making up pipe coils for steam heating and for water tube boilers. They are U-shaped fittings, with a female thread at both ends, and are regularly made in three patterns known as

1. Close.
2. Medium.
3. Open.

Some manufacturers also make an extra close, and extra wide pattern. These patterns represent various widths between the two arms.

There seems to be no standard as to the spacing of the arms for the different patterns, hence for close work *the fitter should ascertain the center to center dimensions from the manufacturer's catalogue of the make to be used.* The table on the following page shows dimensions of the various patterns as made by Jarecki Mfg. Co. Compare with Crane dimensions above.

Return bends smaller than the ½ inch size are difficult to get as very few manufacturers make them, hence it should be noted that the Jarecki return bends are made in the ¼ and ⅜ sizes according to the above list.

Malleable Return Bends

(Dimensions as made by Crane & Co.)

RETURN BENDS, CLOSE OR MEDIUM PATTERNS

Size..........Inches	½	¾	1	1¼	1½	2
Center to Center, Close.....Inches	1	1¼	1½	1¾	2 3/16	2⅝
Center to Center, Medium..Inches	1¼	1½	1⅞	2¼	2½	3

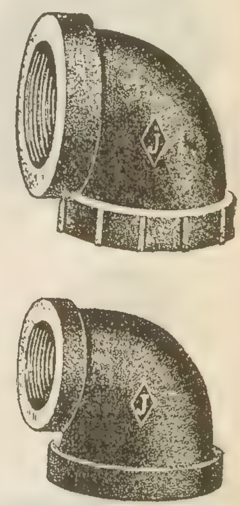
Close Pattern Return Bends will not make up parallel coils, as the distance, center to center, of two adjacent bends is greater than the center to center of openings of a single bend.

RETURN BENDS, OPEN PATTERN

Size..........Inches	½	¾	1	1¼	1½	2	2½	3
Center to Center..........Inches			5	7½	8	6	12	
Center to Center. Inches	1½	2	2½	3	3½	4	4½	5

RETURN BENDS, SPECIAL WIDE PATTERN, RIGHT HAND

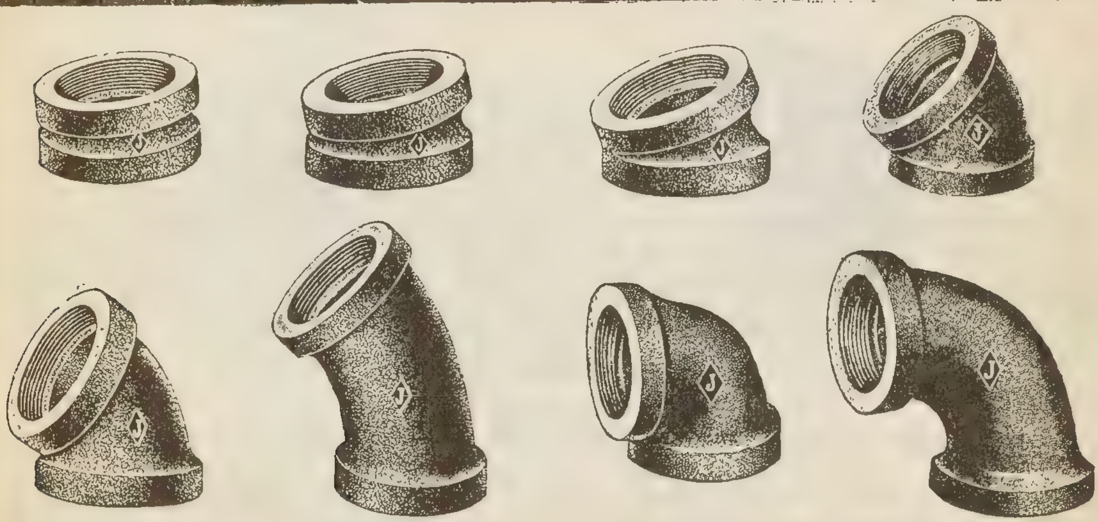
Size..........Inches	⅜	¾	¾	1	1¼	1½
Center to Center..........Inches	1½	4	6	6	6	6



FIGS. 7,849 and 7,850. —Right and left (R and L), and reducing cast iron elbows.

Malleable Return Bends
(Dimensions as manufactured by Jarecki Mfg. Co.)

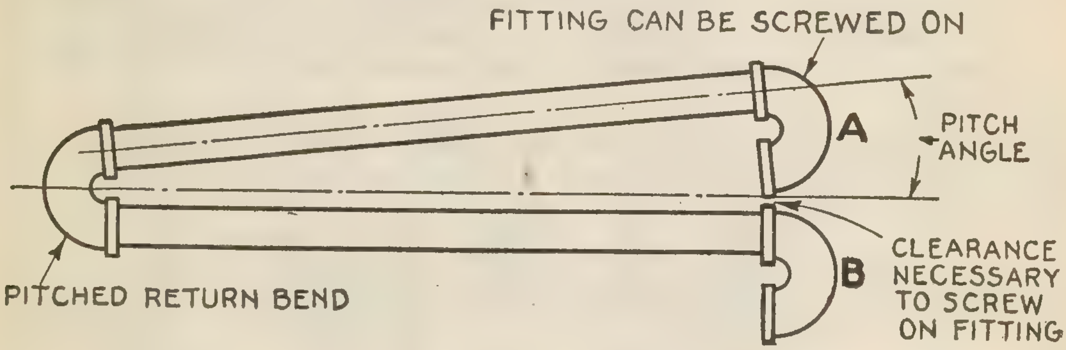
Size	Extra close		Close		Medium		Open		Wide
	Center to center	Weight per 100 plain	Center to center	Weight per 100 banded	Center to center	Weight per 100 banded	Center to center	Weight per 100	Center to center
¼	......	....	¾	15.5	......	....	1⅛	21	....
⅜	......	....	⅞	22	......	....	1¼	22	....
½	......	....	1⅛	35	1¼	34	1½	44	....
¾	1¼	77	1⅜	71	1 9/16	60	2	83	6
1	1 9/16	92	1¾	100	1⅞	92	2½	140	3 4,4½, 5,6,7,8
1¼	......	....	2⅛	168	2¼	160	3	200	4,5,6,9
1½	......	....	2½	244	2 9/16	255	3½	310	5,6,8
2	......	....	2¾	388	3 1/16	337	4⅜	550	2,6,7,8
2½	......	....	3⅞	631	......	....	4¾	710	....
3	......	....	4½	880	......	....	6¼	1,050	....
3½	......	....	5	1,400	......	....	6½	1,550	....
4	......	....	......	....	......	....	7	1,850	....
5	......	....	6	....	......	....	......	....	....

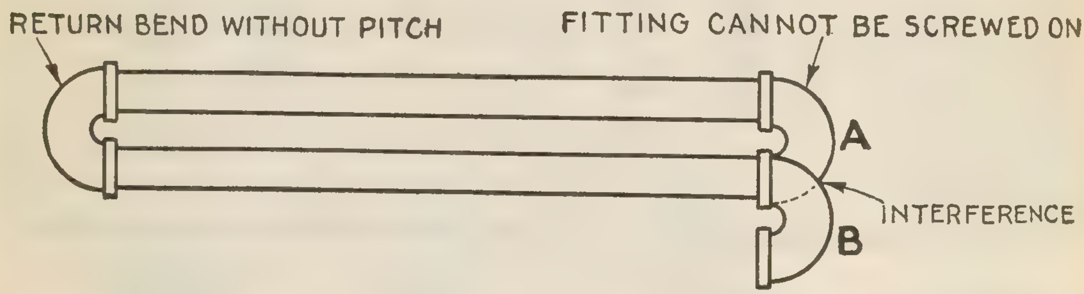


FIGS. 7,851 to 7,858.—Various cast iron drainage elbows. Fig. 7,851, 1/64 bend, or ⅝° elbow, fig. 7,852, 1/32 bend, or 11¼° short elbow; fig. 7,853, 1/16 bend, or 22½° short elbow; fig. 7,854, 1/12 bend, or 30° short elbow; fig. 7,855, ⅛ bend or 45° short elbow; fig. 7,856, ⅛ elbow, or 45° long elbow; fig. 7,857, ¼ bend, or 90° short elbow; fig. 7,858, ¼ bend, or 90° long elbow.

For making up so called "coils" of short lengths of pipe, return bends may be obtained tapped with "pitch."

That is tapped so the pipes when screwed into the fitting will not be parallel but spread like the sides of the letter V. Such bends are usually listed with minimum pipe lengths for which the pitch is suitable. For instance, Crane Co. list such bends as follows:





FIGS. 7,859 and 7,860.—Coil being made up with short pipe lengths and with return bends having "pitch" and no pitch. ***If the threads*** be tapped in the fitting at a slight angle so that the pipes will be inclined to each other as in fig. 7,859, there will be room enough to screw on bend A, without encountering fitting B. ***If the bends*** have no pitch, as in fig. 7,860, then in screwing on bend A, the other bend B, will be in the way, making it difficult to screw on A. Of course this interference may be overcome in special cases by prying the pipe ends apart with a wedge. The author made up a number of ½-inch coils with 2-foot pipe lengths by this method. The minimum length of pipe that can be made up in this way will, of course, depend on the size, and is best determined by experiment. With ½-inch pipe, the 2-foot length is about as short as should be used, though it is probably possible to reduce the length to 1½ feet.

Pitched Return Bends

(Close pattern)

Size in inches..............	1	1	1	1	1	1¼	1¼	1¼
Length of pipe in coil feet..	3	4	5	6	8	4	5	6

4. Branching Fittings

Side Outlet Elbows.—The two openings of an elbow indicate its *run*, and when there is a third opening, the axis of which is at 90° to the plane of the run, the fitting is a side outlet elbow, as

FIGS. 7,861 to 7,865.—Jarecki malleable return bends. Fig. 7,861, close pattern without bead; fig. 7,862 close pattern with bead; fig. 7,863, medium pattern; fig. 7,864, open pattern; fig. 7,865, wide pattern.

FIGS. 7,866 and 7,867.—Jarecki plain or gas pattern malleable and cast iron elbow with side outlet. ***Sizes and weights per 100***; ¼×¼×¼,—lbs; ⅜×⅜×¼, 14 lbs; ⅜×⅜×⅜, 17 pounds; ½×½×⅜, 24 pounds; ½×½×½, 30 pounds; ¾×¾×⅜, 29 pounds; ¾×¾×½, 30 pounds; ¾×¾×¾, 33 pounds; 1×1×⅜, 52 pounds; 1×1×½, 51 pounds; 1×1×¾, 48 pounds; 1×1×1, 55 pounds; 1¼×1¼×1, 110 pounds; 1¼×1¼×1¼, 120 pounds; 1½×1½×1½, 150 pounds; 2×2×2, 200 pounds.

shown in figs. 7,866 and 7,867. These fittings are regularly made in sizes ranging from ¼ to 2 ins. inclusive, with all outlets of equal size, and with side outlet one and two sizes smaller than rim outlets.

In general it is not well to specify too often fittings of this kind which are not so much in demand as the more usual forms because they are sometimes difficult to get.

Back and Side Outlet Return Bends.—These are simply return bends provided with an additional outlet at the back or side as shown respectively in figs. 7,868 and 7,869. They are regularly made in sizes ranging from ¾ to 3 ins. inclusive, in

FIGS 7,868 and 7,869.—Jarecki cast iron return bends with back and side outlet. Fig. 7,868, back outlet fig. 7,869, side outlet.

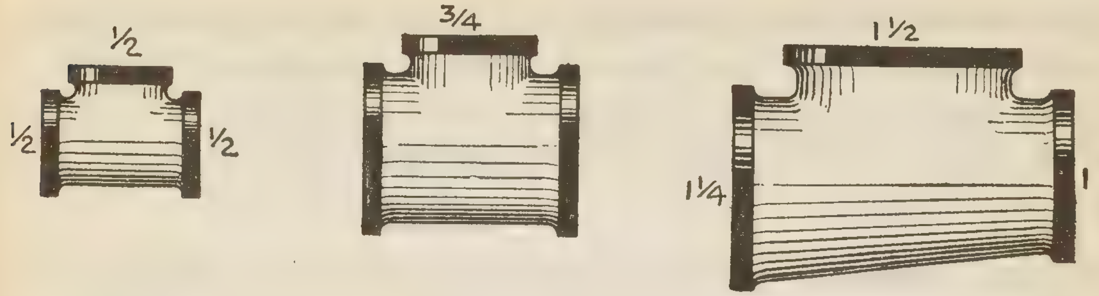
the close or open patterns, tapped right hand or right and left, as follows:

Side and Back Outlet Return Bends

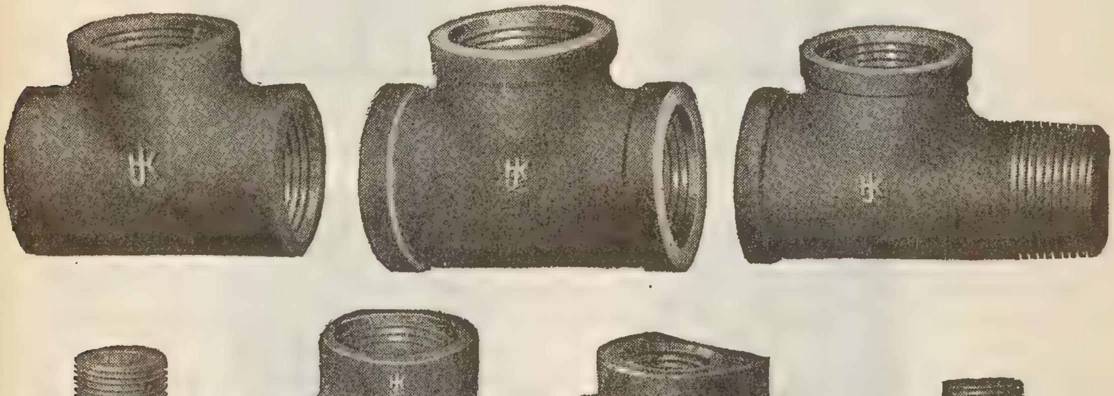
Size	¾	1	1¼	1½	2	2½	3
Center to center, close..........	1½	1⅝	2¼	2½	3	3⅞	4½
Center to center, open..........	2	2⅜	3⅛	3¼	4	4⅞	6¼

Tees.—These are the most important and widely used of the branching fittings. Tees, like elbows, are made in a multiplicity of size and pattern. They are used for making a branch at 90° to the main pipe, and always have the branch at right angles.

When the three outlets are of the same size, the fitting is



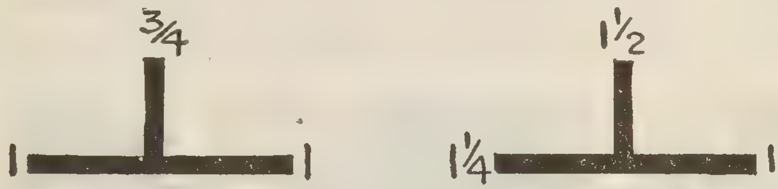
FIGS. 7,870 to 7,872.—System of specifying tees. Fig. 7,870, all outlets the same size, simply give size of pipe; fig. 7,871, branch different size than run, specify run first, thus $1\times\frac{3}{4}$, fig. 7,872, all outlets different size, specify all outlets, run first, thus $1\frac{1}{4}\times1\times1\frac{1}{2}$.



FIGS. 7,873 to 7,881.—Bernard-Greenwood malleable tees. Fig. 7,873, plain tee; fig. 7,874, flat band tee; fig. 7,875, service tee; fig. 7,876, male outlet tee; fig. 7,877, four-way or side outlet tee; fig. 7,878, female drop tee; fig. 7,879, male and female drop tee; fig. 7,880, male and female drop tee, long, with 2½ ins. drop; fig. 7,881, round flange drop tee.

specified by the size of the pipe, as a ½-in. tee; when the branch is of different size than the run outlets, the size of the run is given first as a 1 × ¼ tee; when all three outlets are of different sizes, they are all specified, giving the sizes of the run first as a 1¼ × 1 × 1½ tee.

This method of specifying tees is illustrated in figs. 7,882 and 7,883.



FIGS. 7,882 and 7,883.—Method of specifying tees to avoid possibility of mistakes. ***In ordering fittings,*** simply make a conventional diagram of a tee and put down the dimensions desired.

FIGS. 7,884 and 7,885.—Bernard-Greenwood cast iron ***reducing tees.*** Fig. 7,884, reducing on run; fig. 7,885, reducing on side outlet.

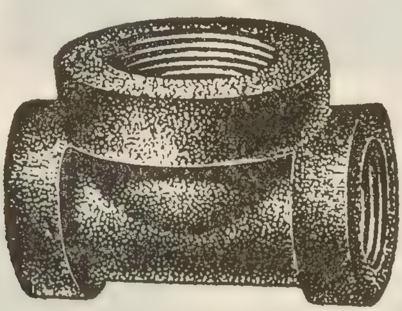


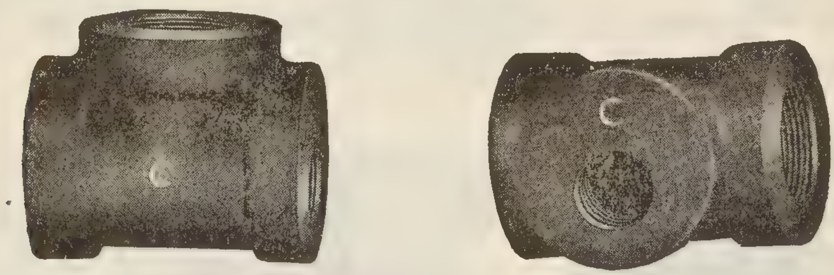
FIG. 7,886.—Cast iron ***enlarging or*** "bull head" tee, enlarging on side outlet.

It is well, however, to avoid mistakes in ordering tees not having all outlets of the same size to make diagrams with dimensions as in figs. 7,882 and 7,883. These variations give rise to a great multiplicity of patterns, of which 183 are listed in one catalogue for sizes, ranging from ⅛ to 6 inch. It should be noted, however, that *the number of patterns usually carried in*

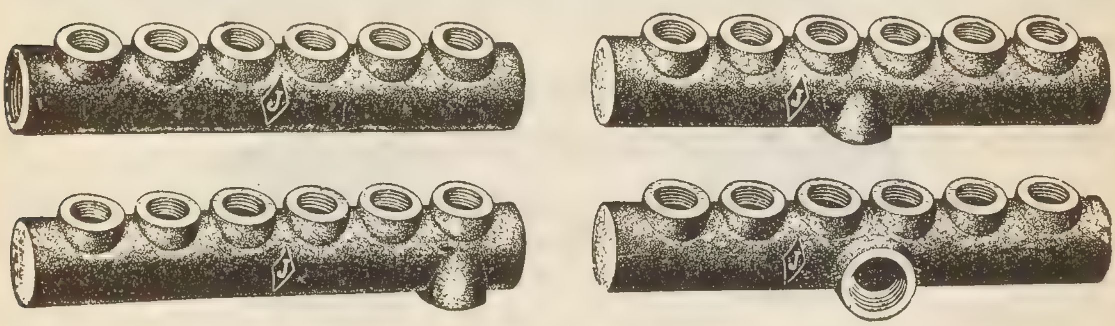
stock is very small, hence it is not advisable in general to specify unusual sizes.

Figs. 7,873 to 7,888 show various tees illustrating the great variety of patterns in use.

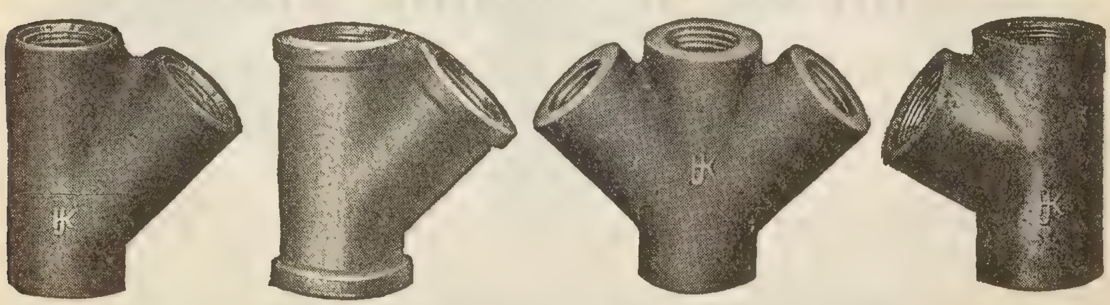
Y Branches.—These are similar to a tee, but have the side



FIGS. 7,887 and 7,888.—Crane cast iron ***eccentric reducing tees.*** Fig. 7,887, eccentric outlet in run; fig. 7,888, eccentric outlet in side. The object of these fittings is to prevent lodging places for water, which condition obtains where double reducing fittings are used. When ordering eccentric tees, it is well to guard against mistakes by sending a sketch showing the exact position in which the fitting is to be placed.



FIGS. 7,889 to 7,892.—Jarecki cast iron branch tees or headers.



FIGS. 7,893 to 7,896.—Kelly-Jones malleable iron Y branches. Fig. 7,893, plain Y branch; fig. 7,894, flat band Y branch; fig. 7,895, double Y branch; fig. 7,896, 60° Y branch.

outlet set at an angle of 45° or 60° instead of 90°. Figs. 7,893 to 7,896 show four styles of malleable iron Y branch. The single 45° Y branches, straight and reducing, are regularly made in sizes ranging from ½ to 4 ins.; the double 45° Y branch, in sizes ranging from ½ to 2 inclusive, and the double 60° pattern in the 2-in. and 2×1½ in. sizes.

Crosses.—A cross is simply an ordinary tee having a back outlet opposite the branch outlet. The axes of the four outlets

Figs. 7,897 and 7,898.—Jarecki malleable iron crosses. Fig. 7,897, plain or gas pattern; fig. 7,898, flat band or steam pattern. The reinforcement sometimes takes the form of a band of circular section.

are in the same plane and at right angles to each other. Crosses, like tees, are made in a multiplicity of sizes.

Regarding it as a tee with a back outlet, the tee part is made in various combinations of sizes, similar to ordinary tees, but the back outlet is always the same size as the opposite outlet, or side outlet, of the tee part.

5. Shut off or Closing Fittings

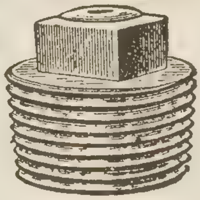
Plugs.—For closing the end of a pipe or a fitting having a female thread, a plug is used. Plugs are made of cast iron, malleable iron, and brass.

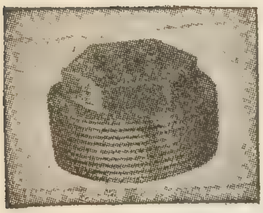
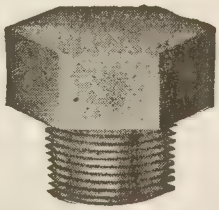
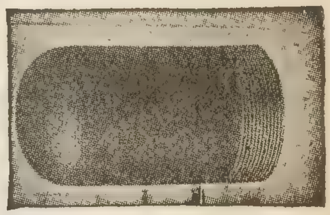
Figs. 7,899 to 7,904 show the patterns: hollow, solid, counter sunk, and diamond design.

Usually a square head or four side counter sunk is used for the small sizes, as in fig. 7,899 to 7,901, and a hexagon head for the larger sizes.

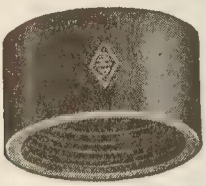
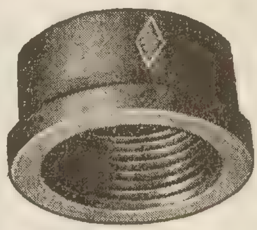
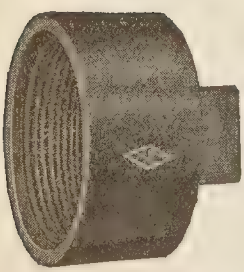
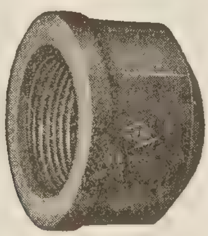
Ordinary plugs are made in sizes ranging from ⅛ to 12 ins. inclusive.

Fig, 7,903 shows a Crane special hydraulic rolled steel plug for cold water or oil working pressures up to 6,000 lbs., sizes ⅜ to 2 ins. inclusive. A

FIGS. 7,899 to 7,904.—Various plugs. Figs. 7,899 to 7,901, hollow, solid and countersunk cast iron plugs; fig. 7,902, Bernard-Greenwood hexagon head or diamond design cast iron plug; fig. 7,903, Crane special hydraulic rolled steel plug for 6,000 lbs. pressure; fig. 7,904, Jarecki bull plug made of wrought iron pipe in sizes ranging from 2 in. to 18 in. (O. D.) inclusive.


FIGS. 7,905 to 7,909.—Various caps. Figs. 7,905 and 7,906, M. I. F. Co. malleable iron caps, fig. 7,905, plain for gas or low pressure; fig. 7,906, flat band for steam; fig. 7,907, square head 1½ in. and smaller (hexagon head 2 in. and larger); fig. 7,908 drive cap; fig. 7,909, Bernard-Greenwood cast iron ribbed pattern cap.

special form of plug suitable for closing large openings is the bull plug shown in fig. 7,904.

Caps.—For closing the end of a pipe or fitting having a male thread, a cap is used. These, like plugs, are made of cast iron, malleable iron, and brass. Figs. 7,905 to 7,909 show various cap designs. Plain and flat band or beaded caps are regularly made in sizes from ⅛ to 6 ins. inclusive; cast iron caps from ⅜ to 15 ins. inclusive, being of plain pattern 2 ins. and smaller, and of ribbed pattern 2½ ins. and larger.

Blind Flanges.—These (sometimes called *blank* flanges), are simply cast iron discs for closing flanged fittings or flanged pipe lines.

Figs. 7,910 and 7,911.—Cast iron blind flanges.

Size of Valve or Fitting and O. D. of Flange, Inches	Size of Valve or Fitting and O.D. of Flange, Inches
1x4	12x19
1¼x4½	14x21
1½x5	15x22¼
2x6	16x23½
2½x7	18x25
3x7½	20x27½
3½x8½	22x29½
4x9	24x32
4½x9¼	26x34¼
5x10	28x36½
6x11	30x38¾
7x12½	32x41¾
8x13½	34x43¾
9x15	36x46
10x16	

STANDARD COMPANION FLANGES

CAST IRON, MALLEABLE IRON, FERROSTEEL; CAST STEEL, FORGED STEEL

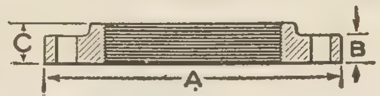


FIG. 7,912.—Dimensions of Crane standard companion flanges.

Size . . . . Inches	¾	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
Size . . . . Millimeters	19	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600
A—Diameter of Flange . . In.	3½	4	4½	5	6	7	7½	8½	9	9¼	10	11	12½	13½	15	16	19	21	22¼	23½	25	27½	29½	32
B—Thickness of Flange . . In.	7/16	7/16	½	9/16	5/8	11/16	¾	13/16	15/16	15/16	15/16	1	1 1/16	1 1/8	1 1/8	1 3/16	1¼	1 3/8	1 3/8	1 7/16	1 9/16	1 11/16	1 13/16	1 7/8
C—Length of Hub . . . . In.	5/8	11/16	¾	7/8	1	1 1/16	1 1/8	1 3/16	1 3/16	1¼	1 5/16	1 7/16	1½	1 5/8	1¾	1 7/8	2 1/16	2 3/16	2 5/16	2 7/16	2 5/8	2¾	2 7/8	3

NOTE—Sizes 14-in. and larger are tapped for O. D. pipe.

EXTRA HEAVY COMPANION FLANGES

CAST IRON, MALLEABLE IRON, FERROSTEEL, CAST STEEL, FORGED STEEL

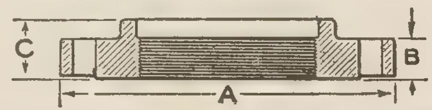


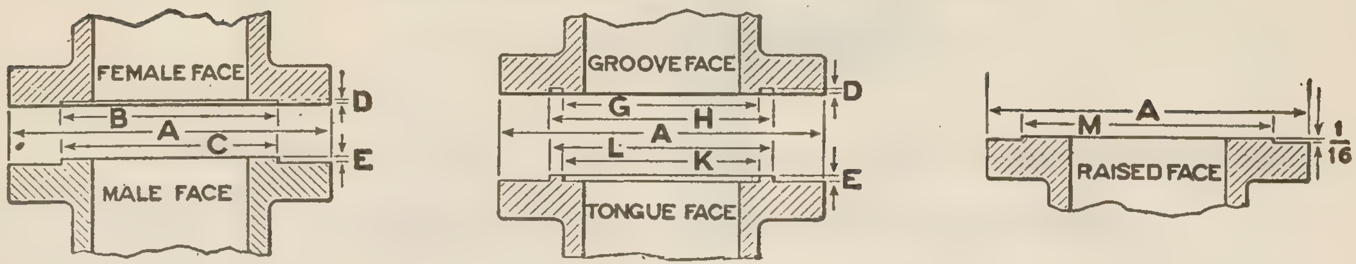
FIG. 7,913.—Dimensions of Crane extra heavy companion flanges.

Size . . . . Inches	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
Size . . . . Millimeters	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600
A—Diameter of Flange . . . . . Inches	4½	5	6	6½	7½	8¼	9	10	10½	11	12½	14	15	16¼	17½	20½	23	24½	25½	28	30½	33	36
B—Thickness of Flange . . . . Inches	11/16	¾	13/16	7/8	1	1 1/8	1 3/16	1¼	1 5/16	1 3/8	1 7/16	1½	1 5/8	1¾	1 7/8	2	2 1/8	2 3/16	2¼	2 3/8	2½	2 5/8	2¾
C—Length of Hub . . . . Inches	1	1 1/8	1¼	1 3/8	1 7/16	1 9/16	1 5/8	1¾	1 13/16	1 7/8	2	2 1/16	2 3/16	2¼	2 3/8	2 9/16	2 11/16	2 13/16	2 7/8	3 1/16	3¼	3 7/16	3 5/8

EXTRA HEAVY FLANGES

CAST IRON, FERROSTEEL AND CAST STEEL

GENERAL DIMENSIONS OF VARIOUS FACINGS



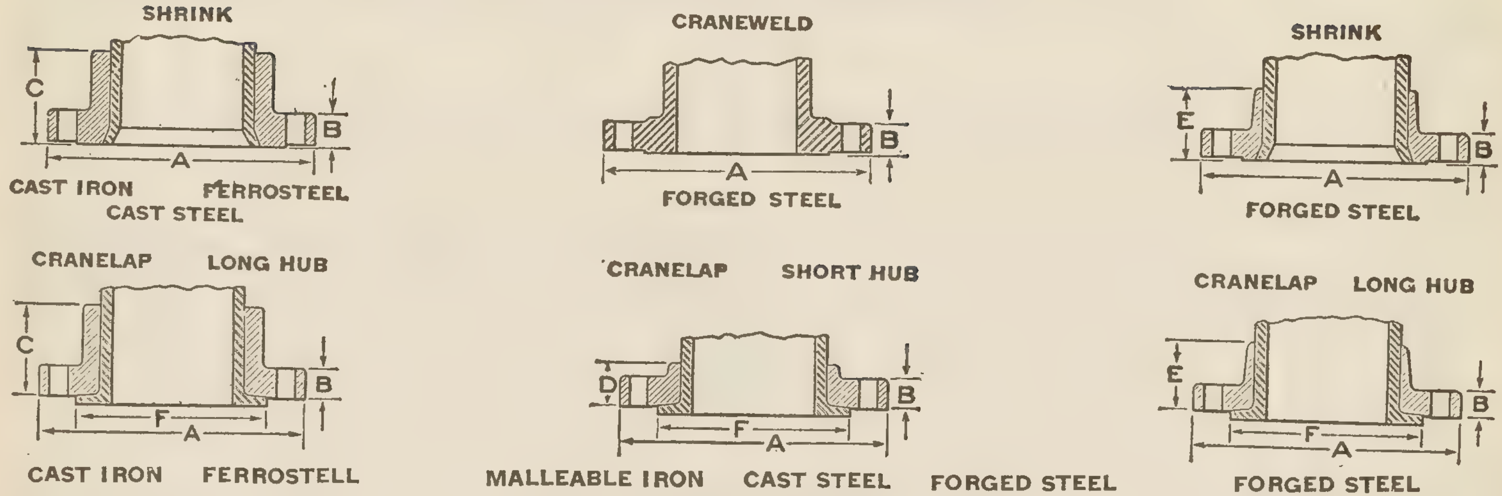
FIGS. 7,914 to ,7916.—Various extra heavy cast iron ferrosteel and cast steel flanges; dimensions of facings.

Size .... Inches	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6	7	8	9	10	12	14	15	16	18	20	22	24
Size .... Millimeters	25	32	38	50	64	76	90	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600
A-Diameter of Flange ...... Inches	4 1/2	5	6	6 1/2	7 1/2	8 1/4	9	10	10 1/2	11	12 1/2	14	15	16 1/4	17 1/2	20 1/2	23	24 1/2	25 1/2	28	30 1/2	33	36
B-Diameter Recess, Female. . Inches	2 3/8	2 13/16	3 3/16	3 11/16	4 3/16	5 1/16	5 9/16	6 1/16	6 9/16	7 5/16	8 7/16	9 7/16	10 11/16	11 11/16	12 13/16	15 5/16	16 9/16	17 9/16	18 9/16	21 1/16	23 1/16	25 9/16	27 9/16
C-Diameter of Male .... Inches	2 5/16	2 3/4	3 1/8	3 5/8	4 1/8	5	5 1/2	6	6 1/2	7 1/4	8 3/8	9 3/8	10 5/8	11 5/8	12 3/4	15 1/4	16 1/2	17 1/2	18 1/2	21	23	25 1/2	27 1/2
D-Depth of Recess .... Inches	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
E-Height of Face .... Inches	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
G-Inside Diameter Groove . . Inches	1 11/16	2 1/16	2 11/16	3 1/16	3 9/16	4 3/16	4 11/16	5 3/16	5 11/16	6 3/16	7 7/16	8 9/16	9 9/16	10 9/16	11 9/16	13 9/16	15 13/16	17 1/16	18 5/16	20 5/16	22 1/4	24 7/16	26 7/16
H-Outside Diameter Groove. Inches	2 9/16	3 1/16	3 11/16	4 3/16	4 11/16	5 5/16	5 13/16	6 5/16	6 13/16	7 5/16	8 9/16	9 11/16	10 15/16	11 15/16	13 3/16	15 3/16	17 7/16	18 11/16	20 3/16	22 7/16	24 3/8	26 9/16	28 9/16
K-Inside Diameter Tongue. . Inches	1 3/4	2 1/8	2 3/4	3 1/8	3 5/8	4 1/4	4 3/4	5 1/4	5 3/4	6 1/4	7 1/2	8 5/8	9 5/8	10 5/8	11 5/8	13 5/8	15 7/8	17 1/8	18 3/8	20 3/8	22 5/16	24 1/2	26 1/2
L-Outside Diameter Tongue. Inches	2 1/2	3	3 5/8	4 1/8	4 5/8	5 1/4	5 3/4	6 1/4	6 3/4	7 1/4	8 1/2	9 5/8	10 7/8	11 7/8	13 1/8	15 1/8	17 3/8	18 5/8	20 1/8	22 3/8	24 5/16	26 1/2	28 1/2
M-Diameter of Raised Face Cast Iron and Ferrosteel. . . . Inches	2 9/16	3 1/16	3 11/16	4 3/16	4 15/16	5 11/16	6 5/16	6 15/16	7 9/16	8 5/16	9 11/16	10 13/16	11 15/16	12 13/16	14 1/16	16 7/16	18 15/16	20 1/16	21 1/16	23 5/16	25 7/16	27 9/16	30 3/16
M-Diam. of Raised Face—Steel. In.	2	2 1/4	2 7/8	3 5/8	4 1/8	5	5 1/2	6 3/16	6 3/4	7 5/16	8 1/2	9 5/8	10 5/8	11 5/8	12 3/4	15	17 1/4	18 3/8	19 3/8	21 1/2	23 1/2	25 1/4	27 1/4

EXTRA HEAVY FLANGES

CRANELAP CRANEWELD SHRINK

GENERAL DIMENSIONS



FIGS. 7,917 to 7,922.—Various extra heavy flanges; general dimensions.

Size ... Inches	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
Size ... Millimeters	100	113	125	150	175	200	225	250	300	350	375	400	450	500	550	600
A—Diameter of Flange ... Inches	10	10½	11	12½	14	15	16¼	17½	20½	23	24½	25½	28	30½	33	36
B—Thickness of Flange ... Inches	1¼	1$\frac{5}{16}$	1⅜	1$\frac{7}{16}$	1½	1⅝	1¾	1⅞	2	2⅛	2$\frac{3}{16}$	2¼	2⅜	2½	2⅝	2¾
C—Length of Hub, Regular ... Inches	3¾	3$\frac{15}{16}$	4⅛	4¼	4$\frac{7}{16}$	4⅝	4$\frac{13}{16}$	4$\frac{15}{16}$	5$\frac{5}{16}$	5½	5⅝	6	6¼	6½	6⅞	7¼
D—Length of Hub, Short ... Inches	1¾	1$\frac{13}{16}$	1⅞	2	2$\frac{1}{16}$	2$\frac{3}{16}$	2¼	2⅜	2$\frac{9}{16}$	2$\frac{11}{16}$	2$\frac{13}{16}$	2⅞	3$\frac{1}{16}$	3¼	3$\frac{7}{16}$	3⅝
E—Length of Hub, Forged Steel ... Inches	3¼	3$\frac{5}{16}$	3⅜	3$\frac{7}{16}$	3$\frac{9}{16}$	3¾	3$\frac{15}{16}$	4⅛	4⅜	4¾	4⅞	5⅛	5⅜	5⅞	6⅛	6$\frac{9}{16}$
F—Diameter of Lap ... Inches	6$\frac{3}{16}$	6¾	7$\frac{5}{16}$	8½	9⅝	10⅝	11⅝	12¾	15	17¼	18⅜	19⅜	21½	23½	25¾	27¾

TEMPLATES FOR DRILLING

STANDARD AND LOW PRESSURE FLANGED VALVES AND FITTINGS

AMERICAN STANDARD

EFFECTIVE JANUARY 1, 1914

Size Inches	Size Millimeters	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts Inches	Size of Bolts Inches	Length of Bolts Inches	Length of Studs with 2 Nuts Inches
1	25	4	7/16	3	4	7/16	1½	
1¼	32	4½	½	3⅜	4	7/16	1½	
1½	38	5	9/16	3⅞	4	½	1¾	
2	50	6	⅝	4¾	4	⅝	2	
2½	64	7	11/16	5½	4	⅝	2¼	
3	76	7½	¾	6	4	⅝	2¼	
3½	90	8½	13/16	7	4	⅝	2½	
4	100	9	15/16	7½	8	⅝	2¾	
4½	113	9¼	15/16	7¾	8	¾	2¾	
5	125	10	15/16	8½	8	¾	2¾	
6	150	11	1	9½	8	¾	3	
7	175	12½	1 1/16	10¾	8	¾	3	
8	200	13½	1⅛	11¾	8	¾	3¼	
9	225	15	1⅛	13¼	12	¾	3¼	
10	250	16	1 3/16	14¼	12	⅞	3½	
12	300	19	1¼	17	12	⅞	3½	
14	350	21	1⅜	18¾	12	1	4	
15	375	22¼	1⅜	20	16	1	4	
16	400	23½	1 7/16	21¼	16	1	4	
18	450	25	1 9/16	22¾	16	1⅛	4½	
20	500	27½	1 11/16	25	20	1⅛	4¾	
22	550	29½	1 13/16	27¼	20	1¼	5	
24	600	32	1⅞	29½	20	1¼	5¼	
26	650	34¼	2	31¾	24	1¼	5½	
28	700	36½	2 1/16	34	28	1¼	5½	
30	750	38¾	2⅛	36	28	1⅜	5¾	
32	800	41¾	2¼	38½	28	1½	6¼	
34	850	43¾	2 5/16	40½	32	1½	6½	
36	900	46	2⅜	42¾	32	1½	6½	
38	950	48¾	2⅜	45¼	32	1⅝	6¾	9
40	1000	50¾	2½	47¼	36	1⅝	7	9

TEMPLATES FOR DRILLING

BRASS FLANGED VALVES AND FITTINGS

"HEAVY" FOR PRESSURES UP TO 150 POUNDS

Size Inches	Size Millimeters	Diameter of Flange Inches	Thickness of Flange Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches
¼ and ⅜	6 and 10	2½	9/32	1 11/16	4	⅜	1
½	13	3	5/16	2⅛	4	⅜	1¼
¾	19	3½	11/32	2½	4	⅜	1¼
1	25	4	⅜	3	4	7/16	1¼
1¼	32	4½	13/32	3⅜	4	7/16	1½
1½	38	5	7/16	3⅞	4	½	1½
2	50	6	½	4¾	4	⅝	1¾
2½	64	7	9/16	5½	4	⅝	2
3	76	7½	⅝	6	4	⅝	2
3½	90	8½	11/16	7	8	⅝	2¼
4	100	9	11/16	7½	8	⅝	2¼
4½	113	9¼	23/32	7¾	8	¾	2½
5	125	10	¾	8½	8	¾	2½
6	150	11	13/16	9½	8	¾	2¾
7	175	12½	⅞	10¾	8	¾	2¾
8	200	13½	15/16	11¾	8	¾	3
9	225	15	15/16	13¼	12	¾	3
10	250	16	1	14¼	12	⅞	3¼
12	300	19	1 1/16	17	12	⅞	3¼

"EXTRA HEAVY" FOR PRESSURES UP TO 250 POUNDS

Size Inches	Size Millimeters	Diameter of Flange Inches	Thickness of Flange Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches
¼ and ⅜	6 and 10	3	⅜	2	4	7/16	1¼
½	13	3½	13/32	2⅜	4	7/16	1½
¾	19	4	7/16	2⅞	4	½	1½
1	25	4½	½	3¼	4	½	1¾
1¼	32	5	17/32	3¾	4	½	1¾
1½	38	6	9/16	4½	4	⅝	2
2	50	6½	⅝	5	4	⅝	2
2½	64	7½	11/16	5⅞	4	¾	2¼
3	76	8¼	¾	6⅝	8	¾	2½
3½	90	9	13/16	7¼	8	¾	2¾
4	100	10	⅞	7⅞	8	¾	2¾
4½	113	10½	⅞	8½	8	¾	2¾
5	125	11	15/16	9¼	8	¾	3
6	150	12½	1	10⅝	12	¾	3
7	175	14	1 1/16	11⅞	12	⅞	3¼
8	200	15	1⅛	13	12	⅞	3½
9	225	16¼	1⅛	14	12	1	3½
10	250	17½	1 3/16	15¼	16	1	3¾
12	300	20½	1¼	17¾	16	1⅛	4

TEMPLATES FOR DRILLING

STANDARD AND LOW PRESSURE FLANGED VALVES AND FITTINGS

AMERICAN STANDARD

EFFECTIVE JANUARY 1, 1914
CONTINUED

Size Inches	Size Millimeters	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts Inches	Size of Bolts Inches	Length of Bolts Inches	Length of Studs with 2 Nuts Inches
42	1050	53	2⅝	49½	36	1⅝	7¼	9½
44	1100	55¼	2⅝	51¾	40	1⅝	7¼	9½
46	1150	57¼	1 11/16	53¾	40	1⅝	7½	9½
48	1200	59½	2¾	56	44	1⅝	7½	9½
50	1250	61¾	2¾	58¼	44	1¾	7¾	10
52	1300	64	2⅞	60½	44	1¾	8	10½
54	1350	66¼	3	62¾	44	1¾	8¼	10½
56	1400	68¾	3	65	48	1¾	8¼	10½
58	1450	71	3⅛	67¼	48	1¾	8½	11
60	1500	73	3⅛	69¼	52	1¾	8½	11
62	1550	75¾	3¼	71¾	52	1⅞	9	11½
64	1600	78	3¼	74	52	1⅞	9	11½
66	1650	80	3⅜	76	52	1⅞	9¼	11½
68	1700	82¼	3⅜	78¼	56	1⅞	9¼	11½
70	1750	84½	3½	80½	56	1⅞	9½	12
72	1800	86½	3½	82½	60	1⅞	9½	12
74	1850	88½	3⅝	84½	60	1⅞	9¾	12
76	1900	90¾	3⅝	86½	60	1⅞	9¾	12
78	1950	93	3¾	88¾	60	2	10	12½
80	2000	95¼	3¾	91	60	2	10	12½
82	2050	97½	3⅞	93¼	60	2	10½	13
84	2100	99¾	3⅞	95½	64	2	10½	13
86	2150	102	4	97¾	64	2	10½	13
88	2200	104¼	4	100	68	2	10½	13
90	2250	106½	4⅛	102¼	68	2⅛	11	14
92	2300	108¾	4⅛	104½	68	2⅛	11	14
94	2350	111	4¼	106¼	68	2⅛	11¼	14
96	2400	113¼	4¼	108½	68	2¼	11½	14½
98	2450	115½	4⅜	110¾	68	2¼	11½	14½
100	2500	117¾	4⅜	113	68	2¼	11½	14½

AMERICAN STANDARD

TEMPLATES FOR DRILLING

EXTRA HEAVY AND MEDIUM FLANGED VALVES AND EXTRA HEAVY FLANGED FITTINGS

Size Inches	Size Millimeters	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches	Length of Studs with 2 Nuts Inches
1	25	4½	11/16	3¼	4	½	2	
1¼	32	5	¾	3¾	4	½	2¼	
1½	38	6	13/16	4½	4	⅝	2½	
2	50	6½	⅞	5	4	⅝	2½	
2½	64	7½	1	5⅞	4	¾	3	
3	76	8¼	1⅛	6⅝	8	¾	3¼	
3½	90	9	1 3/16	7¼	8	¾	3¼	
4	100	10	1¼	7⅞	8	¾	3½	
4½	113	10½	1 5/16	8½	8	¾	3½	
5	125	11	1⅜	9¼	8	¾	3¾	
6	150	12½	1 7/16	10⅝	12	¾	3¾	
7	175	14	1½	11⅞	12	⅞	4	
8	200	15	1⅝	13	12	⅞	4¼	
9	225	16¼	1¾	14	12	1	4¾	
10	250	17½	1⅞	15¼	16	1	5	
12	300	20½	2	17¾	16	1⅛	5¼	
14	350	23	2⅛	20¼	20	1⅛	5½	
15	375	24½	2 3/16	21½	20	1¼	5¾	
16	400	25½	2¼	22½	20	1¼	6	
18	450	28	2⅜	24¾	24	1¼	6¼	
20	500	30½	2½	27	24	1⅜	6½	
22	550	33	2⅝	29¼	24	1½	7	
24	600	36	2¾	32	24	1⅝	7½	9½
26	650	38¼	2 13/16	34½	28	1⅝	7¾	10
28	700	40¾	2 15/16	37	28	1⅝	8	10
30	750	43	3	39¼	28	1¾	8¼	10½
32	800	45¼	3⅛	41½	28	1⅞	8½	11
34	850	47½	3¼	43½	28	1⅞	9	11½
36	900	50	3⅜	46	32	1⅞	9¼	11½
38	950	52¼	3 7/16	48	32	1⅞	9¼	11½
40	1000	54½	3 9/16	50¼	36	1⅞	9½	12
42	1050	57	3 11/16	52¾	36	1⅞	9¾	12
44	1100	59¼	3¾	55	36	2	10	12½
46	1150	61½	3⅞	57¼	40	2	10¼	13
48	1200	65	4	60¾	40	2	10½	13

DRILLING TEMPLATES

800 POUND

AMERICAN HYDRAULIC STANDARD

FLANGED VALVES

FLANGES AND FLANGED FITTINGS

FERROSTEEL

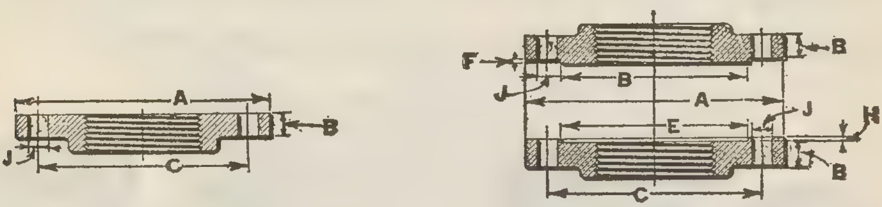
Size Inches	Size Millimeters	Diameter of Flange	Thickness of Flange	Bolt Circle	Number Bolts	Size of Bolts	Length of Bolts	⊕ Diameter Raised or Male Face
½	13	3½	9/16	2⅜	4	7/16	2¼	1⅜
¾	19	4	⅝	2⅞	4	½	2½	1 11/16
1	25	4½	11/16	3¼	4	½	2½	2
1¼	32	5	¾	3¾	4	½	2¾	2¼
1½	38	6	13/16	4½	4	⅝	3	2⅞
2	50	6¾	1¼	5¼	8	⅝	4	3⅝
2½	64	7½	1⅜	5⅞	8	¾	4¼	4⅛
3	76	8½	1½	6½	8	¾	4½	5
3½	90	9½	1⅝	7½	8	⅞	4¾	5½
4	100	10¾	1⅞	8½	8	⅞	5¼	6 3/16
4½	113	11½	2	9¼	8	⅞	5½	6¾
5	125	13	2⅛	10½	8	1	6	7 5/16
6	150	14	2¼	11½	12	1	6¼	8½
7	175	15	2⅜	12½	12	1	6½	9⅝
8	200	16½	2½	13¾	12	1⅛	7	10⅝
9	225	18½	2¾	15½	16	1⅛	7½	11⅝
10	250	20	2⅞	17	16	1¼	7¾	12¾
12	300	22	3	19¼	20	1¼	8	15

NOTE.—***Wrought pipe*** is usually connected in one of three ways, screwed, flanged or leaded joints. Screwed, pipe in sizes from ⅛ in. to 15 ins. inclusive is regularly threaded on the ends, and is connected by means of threaded couplings; flanged, pipe in sizes 1¼ ins. and larger is frequently connected by drilled flanges bolted together, the joint being made by a gasket between the flange faces. Flanges are attached to the pipe in a variety of ways. The most common method for sizes of pipe from 1¼ ins. to 15 ins. inclusive is by screwing them on the pipe. Many prefer peened flanges for the pipe and the latter is then peened over or expanded into a recess in the flange face. Steel flanges are also welded to pipe and low flanges are used by flanging over the pipe ends. When no method of attaching is stated, screwed flanges are always furnished.—*National Tube Co.*

Figs. 7,923 and 7,924 show standard brass, though not of the blind type, flanges with holes drilled, and below is a table of dimensions for standard and extra heavy brass flanges.

Flanges are furnished smooth face and not drilled, unless otherwise ordered.

An important item in regard to flanges is the drilling. Standard dimensions have been adopted for the spacing, size of bolts, etc., by the American Society of Mechanical Engineers, the



FIGS. 7,923 and 7,924.—Brass flanges. Fig. 7,923, *standard* and *extra heavy* plain flange; fig. 7,924, extra heavy and female flanges.

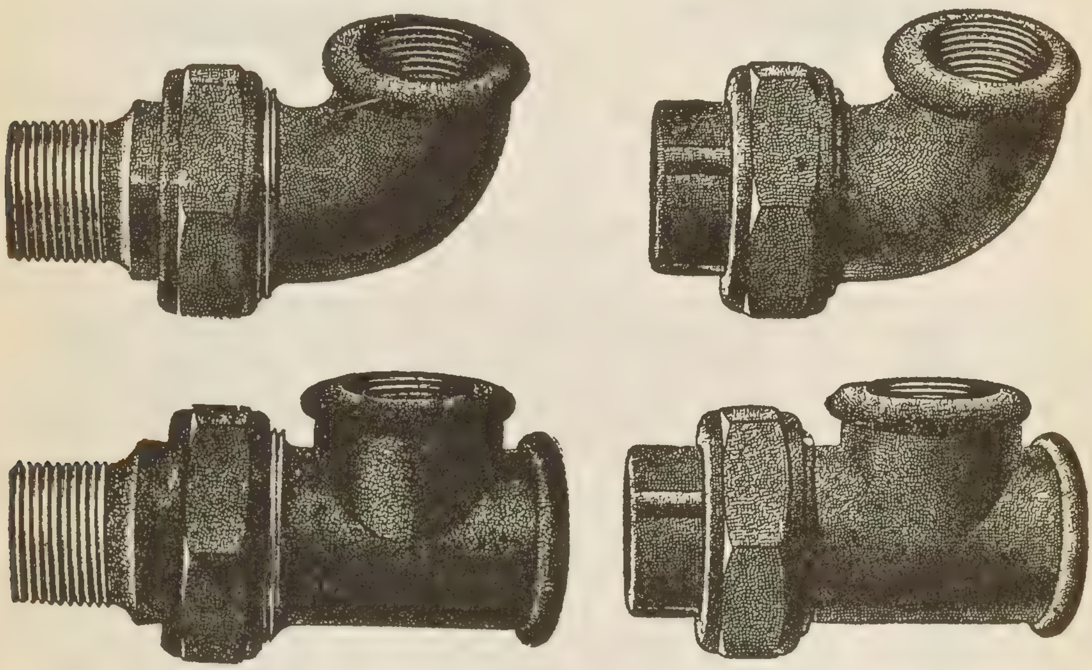
Dimensions of Standard and Extra Heavy Brass Flanges

	Size of Pipe		inches	⅜	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8
A	Diameter of Flange	Standard	inches	2½	3	3½	4	4½	5	6	7	7½	8½	9	9¼	10	11	12½	13½
		Extra Heavy	inches	2½	3	3½	4	4½	5	6	7	7½	8½	9	9¼	10	11	12½	13½
B	Thickness of Flange	Standard	inches	9/32	11/32	⅜	13/32	7/16	15/32	½	9/16	19/32	⅝	21/32	11/16	23/32	25/32	27/32	29/32
		Extra Heavy	inches	11/32	13/32	7/16	½	17/32	9/16	⅝	11/16	23/32	25/32	13/16	27/32	29/32	31/32	1 1/16	1⅛
C	Diameter of Bolt Circle	Standard	inches	1 11/16	2⅛	2½	3	3⅜	3⅞	4¾	5½	6	7	7½	7¾	8½	9½	10¾	11¾
		Extra Heavy	inches	1 11/16	2⅛	2½	2⅞	3⅜	3⅞	4¾	5½	6	7	7½	7¾	8½	9½	10¾	11¾
D	Diameter of Male		inches	1⅛	1 9/16	1 27/32	2 5/32	2 21/32	3 5/32	3 27/32	4 15/32	4 31/32	6 5/32	6 13/32	6 23/32	7 13/32	8 15/32	9 21/32	10 13/32
E	Diameter of Female		inches	1 5/32	1 19/32	1⅞	2 3/16	2 11/16	3 3/16	3⅞	4½	5	6⅛	6½	6¾	7½	8½	9 11/16	10½
F	Height of Male		inches	1/16	3/32	3/32	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	5/32	5/32
H	Depth of Female		inches	1/16	3/32	3/32	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛	5/32	5/32
J	Diameter of Bolt Holes	Standard	inches	7/16	7/16	7/16	½	½	9/16	11/16	11/16	11/16	11/16	13/16	13/16	13/16	13/16	13/16	13/16
		Extra Heavy	inches	7/16	7/16	½	9/16	9/16	9/16	11/16	13/16	13/16	11/16	13/16	13/16	13/16	13/16	13/16	15/16
	Diameter of Bolts	Standard	inch	⅜	⅜	⅜	7/16	7/16	½	⅝	⅝	⅝	⅝	¾	¾	¾	¾	¾	¾
		Extra Heavy	inch	⅜	⅜	7/16	½	½	½	⅝	¾	¾	⅝	¾	¾	¾	¾	¾	⅞
	Length of Bolts	Standard	inches	1⅜	1⅛	1¼	1⅜	1⅜	1½	1¾	1⅞	1⅞	2	2⅛	2¼	2¼	2½	2½	2⅝
		Extra Heavy	inches	1⅜	1¼	1⅜	1⅝	1⅝	1¾	2	2¼	2¼	2¼	2½	2½	2⅝	2¾	3	3¼
	Number of Bolts	Standard	inches	4	4	4	4	4	4	4	4	4	4	4	8	8	8	8	8
		Extra Heavy	inches	4	4	4	4	4	4	4	4	4	8	8	8	8	12	12	12

Master Steam and Hot Water Fitters' Association, and a committee representing the manufacturers of pipe fittings. Tables showing the dimensions adopted for standard and extra heavy cast iron flanges are given on pages **1,964** to **1,965.** The above table which refers to Figs. 7,923 and 7,924 gives the standard for brass.

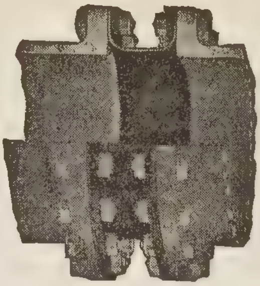
6. Union or make-up Fittings

Union Elbow and Union Tees.—The frequent use of unions in pipe lines is desirable for convenience in case of repairs. Where the union is combined with a fitting, the advantage of a union is obtained with only one threaded joint instead of two, as in the case of a separate union. A disadvantage of union fittings is that they are not as a rule so easily obtainable as ordinary fittings. Figs. 7,925 to 7,928 show union elbows and union tees of the female, and male and female types.



FIGS. 7,925 to 7,928.—Union elbows and union tees. Fig. 7,925, male and female elbow fig. 7,926, female elbow; fig. 7,927, male and female tee; fig. 7,928, female tee. Male and female elbows and tees are sometimes designated as male.

Expansion of Steam Pipes.—The linear expansion and contraction of pipe due to differences of temperature of the fluid carried and the surrounding air, must be cared for by suitable expansion joints or bends.



Figs. 7,929 and 7,930. Crane low pressure copper expansion joints. Fig. 7,929, horizontal or vertical with cast iron screwed flanges; fig. 7,930 horizontal or vertical with steel split rings 25 lbs. working pressure.

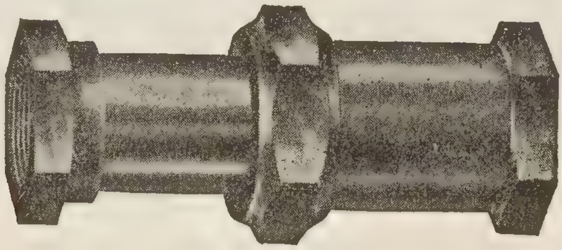


Fig. 7,931.—Crane screwed standard traverse brass expansion joint for 125 lbs. working pressure.

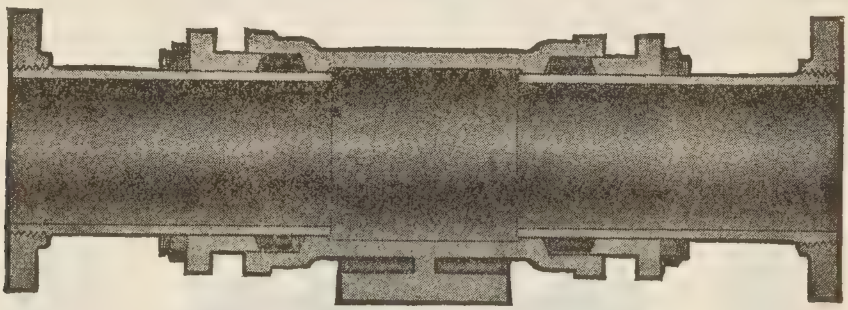


Fig. 7,932.—Crane double expansion joint with anchorage saddle base for 125 lbs. working pressure.

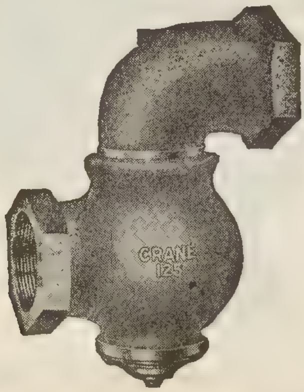
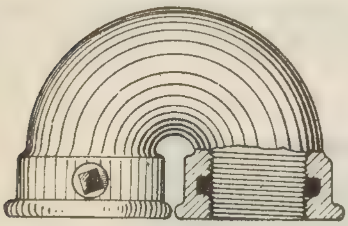
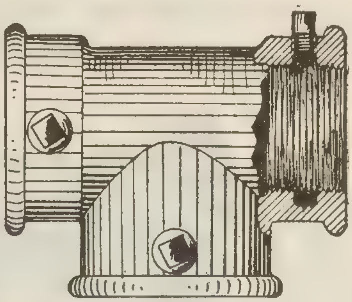


Fig. 7,933.—Crane steam brass swing joint for 125 lbs. working pressure.

In order to determine the amount of expansion or contraction in a pipe line, a table is given showing the increase in length of a pipe 100 ft. long at various temperatures. The expansion for any length of pipe may be found by taking the difference in increased length at the minimum and maximum temperatures, dividing by 100 and mulitplying by the length of the line under consideration.





FIGS. 7,934 and 7,935.—Tight joint fittings. Fig. 7,934, tight joint return bend; fig. 7,935, tight joint tee.

FIG. 7,936.—Walker flexible joint for submerged pipe lines, gas suction or pressure mains. Especially adapted for laying under water where a diver is not employed.

FIG. 7,937.—Kelly and Jones malleable iron railing fittings, having combination angle, screw and slip joint, vertical opening threaded. Angle openings are reamed and drilled for rivets. These fittings are for use on railings between 27½° and 47½° angles. For setting up, the parts are first screwed together and the rails are then fitted and riveted.

FIGS. 7,938 to 7,952.—Crane American Standard Sprinkler cast iron fittings for fire protection service with water working pressures up to 150 lbs. These fittings fill the requirements of the National Fire Protective Association and are made in sizes 2½ to 6 in. inclusive in the various types of elbows, tees and crosses shown. Crane Standard cast iron screwed fittings size 2 in. and smaller, and standard flanged fittings will not have any opening less than 50% of the largest opening. Tappings are provided only for drain or test purposes, in which case fittings are provided with boxes for tapping when required if the location and size of tapping be specified. Fittings 2½ to 6 in. inclusive may be tapped ½ in. on the side without loss and fittings larger than 6 in. may be tapped ¾ in. without loss. All flanges and drilled templates are the American Standard.

EXPANSION OF STEAM PIPES

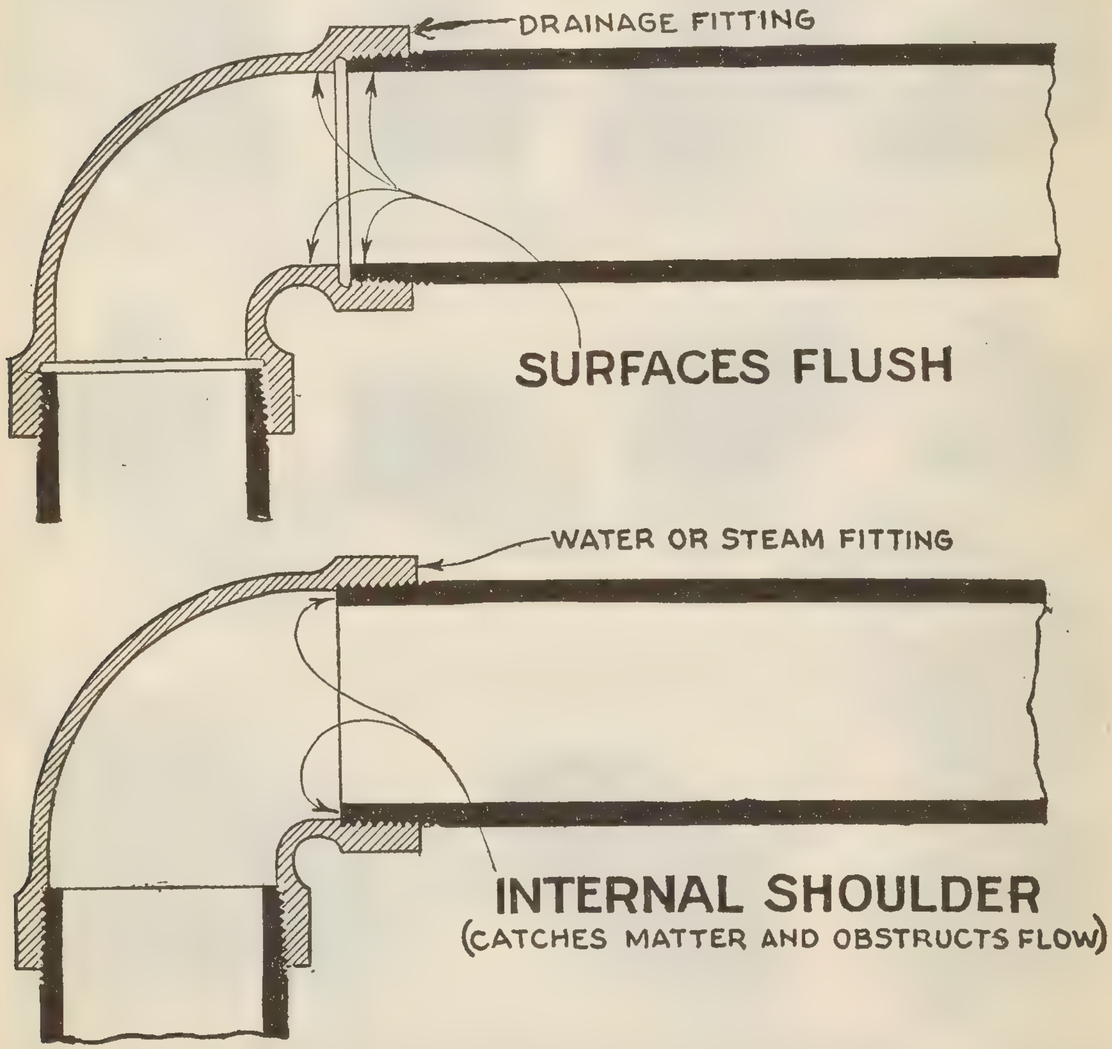
INCREASE IN LENGTH—INCHES PER 100 FEET

Temperature, Degrees F.	Steel	Wrought Iron	Cast Iron	Brass and Copper
0	0	0	0	0
20	.15	.15	.10	.25
40	.30	.30	.25	.45
60	.45	.45	.40	.65
80	.60	.60	.55	.90
100	.75	.80	.70	1.15
120	.90	.95	.85	1.40
140	1.10	1.15	1.00	1.65
160	1.25	1.35	1.15	1.90
180	1.45	1.50	1.30	2.15
200	1.60	1.65	1.50	2.40
220	1.80	1.85	1.65	2.65
240	2.00	2.05	1.80	2.90
260	2.15	2.20	1.95	3.15
280	2.35	2.40	2.15	3.45
300	2.50	2.60	2.35	3.75
320	2.70	2.80	2.50	4.05
340	2.90	3.05	2.70	4.35
360	3.05	3.25	2.90	4.65
380	3.25	3.45	3.10	4.95
400	3.45	3.65	3.30	5.25
420	3.70	3.90	3.50	5.60
440	3.95	4.20	3.75	5.95
460	4.20	4.45	4.00	6.30
480	4.45	4.70	4.25	6.65
500	4.70	4.90	4.45	7.05
520	4.95	5.15	4.70	7.45
540	5.20	5.40	4.95	7.85
560	5.45	5.70	5.20	8.25
580	5.70	6.00	5.45	8.65
600	6.00	6.25	5.70	9.05
620	6.30	6.55	5.95	9.50
640	6.55	6.85	6.25	9.95
660	6.90	7.20	6.55	10.40
680	7.20	7.50	6.85	10.95
700	7.50	7.85	7.15	11.40
720	7.80	8.20	7.45	11.90
740	8.20	8.55	7.80	12.40
760	8.55	8.90	8.15	12.95
780	8.95	9.30	8.50	13.50
800	9.30	9.75	8.90	14.10

CHAPTER 121

Drainage Fittings

The system of pipe fittings commonly known as *drainage fittings* consists of screwed fittings having ***recessed** threads*, as shown in fig. 7,953. These differ from ordinary screwed fittings as shown in figs. 7,953 and 7,954 and the distinction should be



FIGS. 7,953 and 7,954.—Comparison of ***ordinary*** and ***recessed screwed*** or drainage fittings showing reason why ordinary screwed fittings are unsuitable for drainage lines.

carefully noted. Drainage fittings are sometimes called Durham fittings after the name of the inventor.

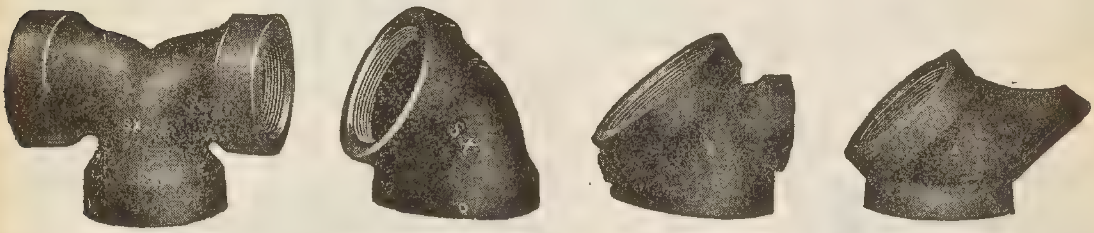
The object of the recessed threads is to bring the surface of the pipe and surface of the fitting flush with each other so that there will not be any projecting shoulder to catch solid matter.

FIGS. 7,955 to 7,958.—Essex cast iron drainage fittings. Fig. 7,955, 90° elbow short turn; fig. 7,956, 90° elbow, long turn; fig. 7,957 45° elbow, short turn; fig. 7,958, 45° elbow, long turn.

FIGS. 7,959 to 7,962.—Essex cast iron drainage fittings. Fig. 7,959 22½° elbow; fig. 7,960, 11¼° elbow; fig. 7,961, 5⅝° elbow; fig. 7,962, 60° elbow.

FIGS. 7,963 to 7,966.—Essex cast iron drainage fittings. Fig. 7,963, 90° elbow, with heel outlet; fig. 7,964, 90° elbow, with side outlet; fig. 7,965, 90° elbow, with cleanout; fig. 7,966, 90° elbow with throat cleanout and soil pipe hub connection.

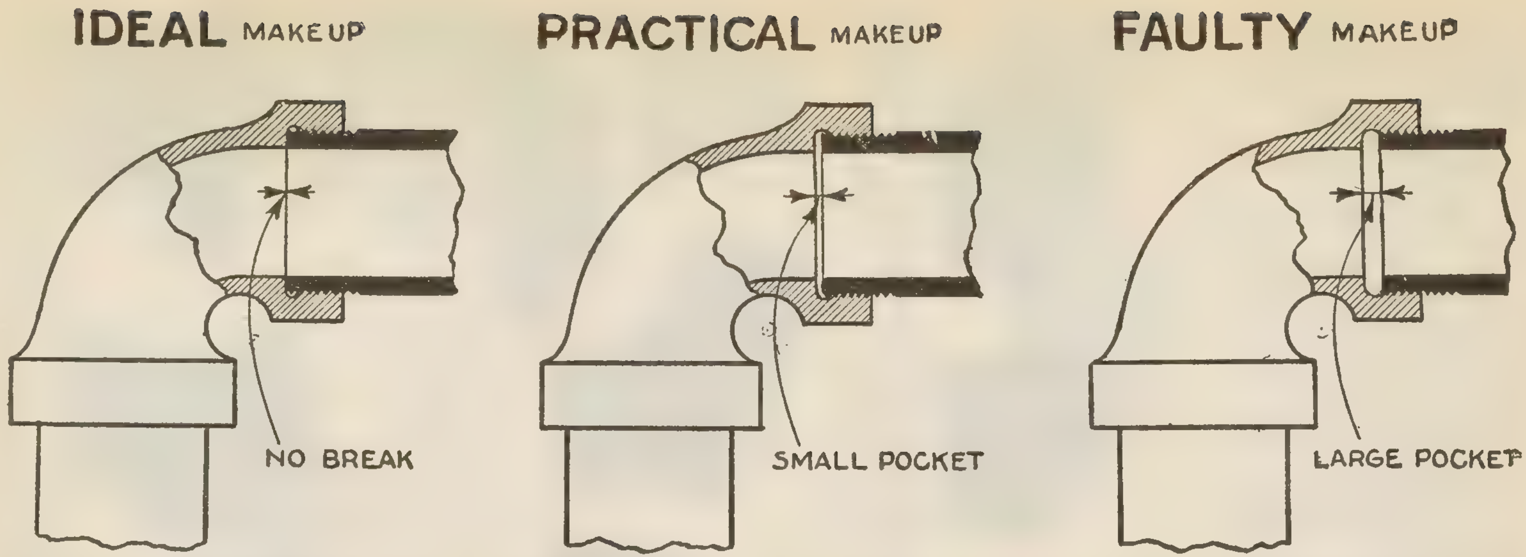
Theoretically, there should be no recess or pocket in which matter could lodge, that is the inside surface of fitting and pipe at the joint should be continuous, the end of the pipe being in contact with the shoulder of the fitting.



FIGS. 7,967 to 7,971.—Essex cast iron drainage fittings. Fig. 7,967, 90° base elbow, with clean-out; fig. 7,668, 3 way elbow; fig. 7,969, 67½° elbow; fig. 7,970, 45° elbow with angle heel outlet; fig. 7,971, 45° elbow with shoe.

FIGS. 7,972 to 7,975.—Essex cast iron drainage fittings. Fig. 7,972, closet elbow, with flange; fig. 7,973, reducing closet elbow; fig. 7,974, long turn 90° elbow, with angle inlets on both sides; fig. 7,975 closet flange.

FIGS. 7,976 to 7,979.—Essex cast iron drainage fittings. Fig. 7,976, short TY; fig. 7,977, long TY; fig. 7,978, reducing short TY; fig. 7,979, reducing long TY.



FIGS. 7,980 to 7,982.—Various degrees of make up for drainage fittings showing effect of adjustment of the dies. Fig. 7,980 shows the ideal joint which as any pipe fitter can see is not feasible in practice. The dies should be adjusted so that the joint will make up as in fig. 7,981, the pipe end very close to the shoulder on the fitting, care being taken to avoid a thread too high with result shown in fig. 7,982.

In practice it would require very fine adjustment of the pipe dies to bring the end of the pipe in contact with the shoulder when the pipe was screwed into the fitting with the proper tightness, and would not be advisable as it would be necessary to change the adjustment for each fitting to allow for any variation in the cut and condition of the surface.

The proper method is to adjust the die so that when the joint is made up the end of the pipe will be very close but not in contact with the shoulder as shown in fig. 7,981.

The results obtained with ordinary fittings and with various degrees of make up of drainage fittings are shown in figs. 7,983 to 7,986. Comparing figs. 7,983 and 7,986 it is seen that even with the joint

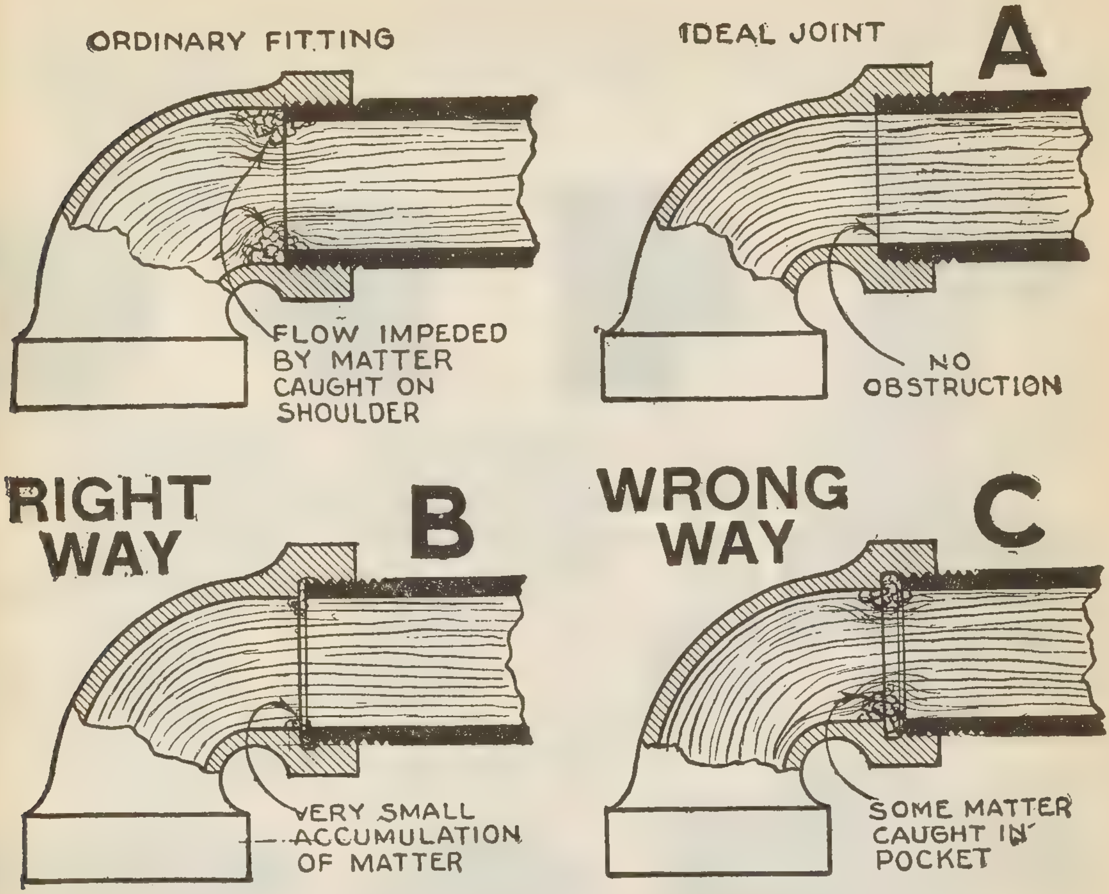


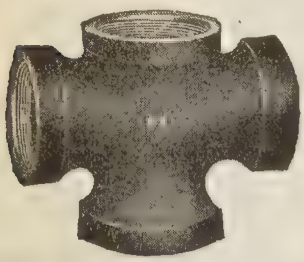
FIG. 7,983.—Ordinary fitting used on soil or waste line showing lodgment of solids on internal shoulder formed by end of pipe with resulting unsatisfactory operation.

FIGS. 7,984 to 7,986.—Various degrees of make up for drainage fittings showing results obtained. **A,** ideal case not commercially practical; **B,** practical make up, very little pocket exposed giving negligible chance for lodgment of matter. **C,** joint improperly made up with too much space between end of pipe and shoulder of fitting forming a pocket where matter may lodge but not to such an extent as would seriously impede the flow as in the case of the ordinary fitting.

FIGS. 7,987 to 7,990.—Essex cast iron drainage fittings. Fig. 7,987, 45° Y; fig. 7,988, double 45° Y; fig. 7,989, reducing 45° Y; fig. 7,990, reducing double 45° Y.

improperly made up as in fig. 7,986 there is less chance for solid matter to lodge in the pocket and build up than with ordinary fittings in which the end of the pipe forms a shoulder as in fig. 7,983. Here the chance for

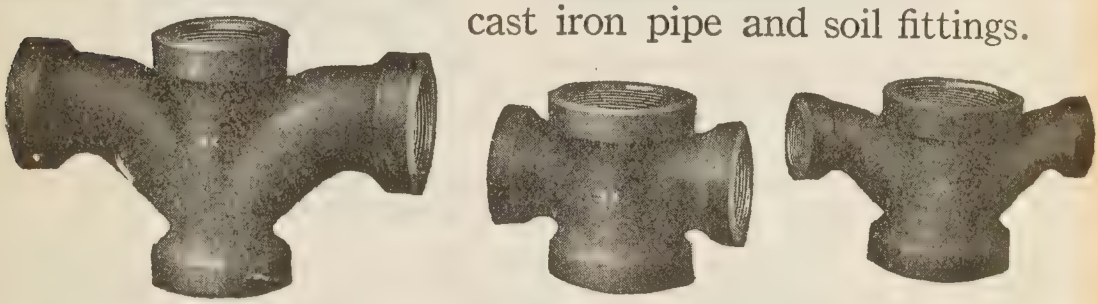
Figs. 7,991 to 7,994.—Essex cast iron drainage fittings. Fig. 7,991, 60° Y; fig. 7,992, T; fig. 7,993, reducing 60° Y; fig. 7,994, reducing T.



lodgement is considerably greater especially in view of the rough surface at the end of the pipe.

On vent lines, either drainage or ordinary fittings may be used.

Since drainage fittings are used with wrought pipe, the installation is lighter than cast iron pipe and soil fittings.

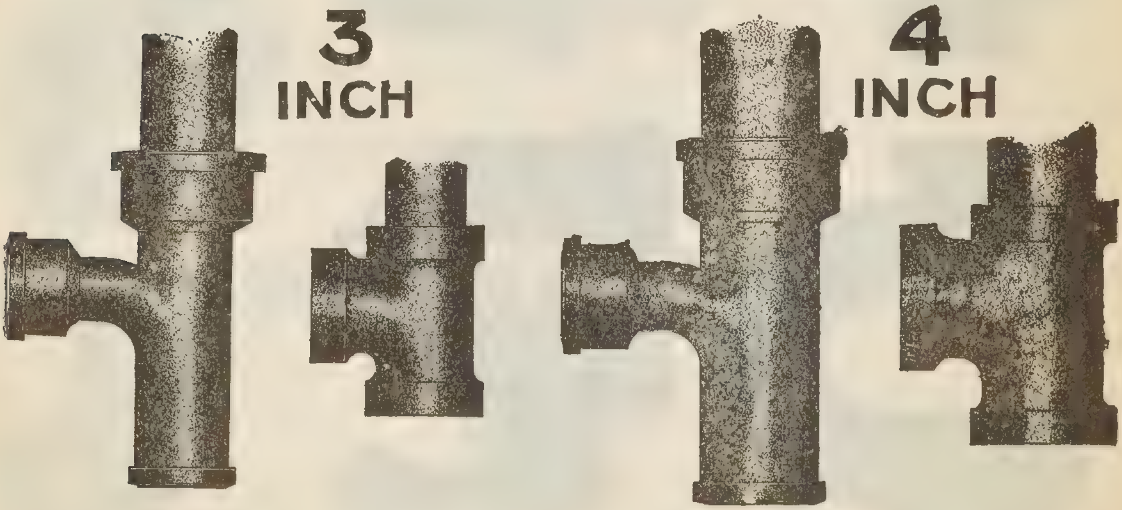


Figs. 7,995 to 7,998.—Essex cast iron drainage fittings. Fig. 7,995, short cross; fig. 7,996, long cross; fig. 7,997, reducing short cross; fig. 7,998, reducing long cross.

Figs. 7,999 to 8,001.—Essex cast iron drainage fittings. Fig. 7,999, basin T; fig. 8,000, basin cross; fig. 8,001, air capping.

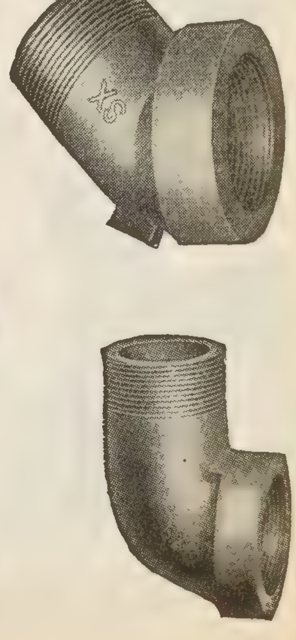
This adapts the system especially to high buildings as the weight to be supported is less. Moreover, less space is required which, for small installations makes it possible to conceal stacks in the frame of the building. The relative space required is shown in figs. 8,007 to 8,010.

FIGS. 8,002 to 8,006.—Essex cast iron drainage fittings. Fig. 8,002, roof connection; fig. 8,003, long turn TY (closet T) with either right or left side inlet; fig. 8,004, long turn TY (closet T) with either right or left side inlet and top inlet; fig. 8,005, increaser; fig. 8,006, offset.



FIGS. 8,007 to 8,010.—Space required for soil fittings and cast iron pipe as compared with drainage fittings and wrought pipe.

FIGS. 8,011 to 8,015.—Essex cast iron drainage fittings. Fig. 8,011, running trap; fig. 8,012, ½ S trap; fig. 8,013, ¾ S trap; fig. 8,014, S trap; fig. 8,015 ½ S trap, no vent.



FIGS. 8,016 and 8,017.—Essex cast iron drainage fittings. Fig. 8,016, 90° street elbow; fig. 8,017, 45° street elbow.

One disadvantage of the Durham system is that the wrought pipe is not as durable as cast iron or soil pipe. This can be offset by using extra heavy pipe, however, in this connection it should be noted that the extra thickness of the pipe is had at the expense of reducing the inside diameter of the pipe. Figs. 8,007 to 8.010 show this reduction for 3 and 4 inch pipe.

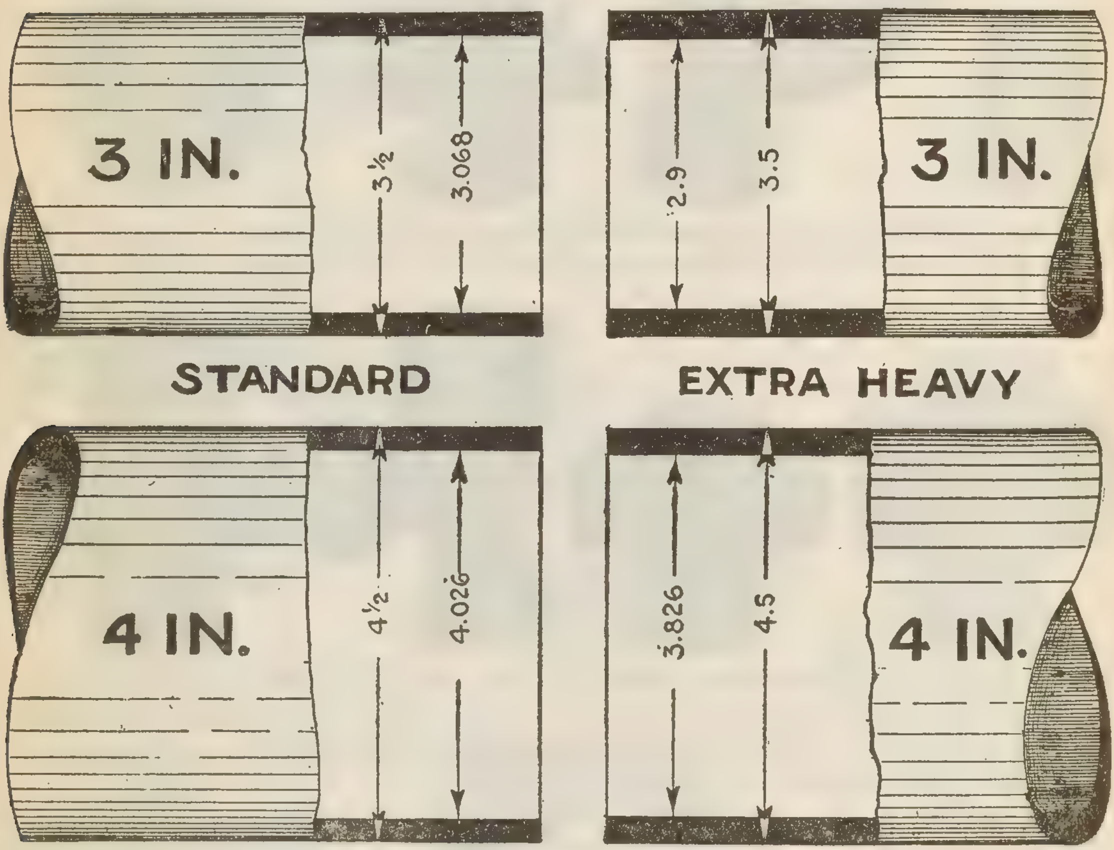
Figs. 8,018 to 8,021.—Essex cast iron drainage fittings. Fig. 8,018, Tucker connection; fig. 8,019, special upright Y; fig. 8,020, reducing double 60° Y; fig. 8,021, sink coupling.

Figs. 8,022 to 8,025.—Essex cast iron drainage fittings. Fig. 8,022, special double TY, short branch, long body, for narrow wall or close connection; fig. 8,023, special reducing double TY, short branch, long body, for narrow wall or close connection; fig. 8,024, special TY, with hub for soil or wrought pipe connection; fig. 8,025, special double TY, with hub for soil or wrought pipe connection.

Figs. 8,026 to 8,028.—Essex cast iron drainage fittings. Fig 8,026, special long TY; fig. 8,027, special long double TY; fig. 8,028, coupling.

Drainage fittings are made either in cast iron or malleable iron, the latter made from the cast iron patterns. They are coated with heated asphaltum excepting those for use in New York City which are not coated.

They are chamfered to prevent damage to the threads and permit easy entrance of the pipe in making up joints.

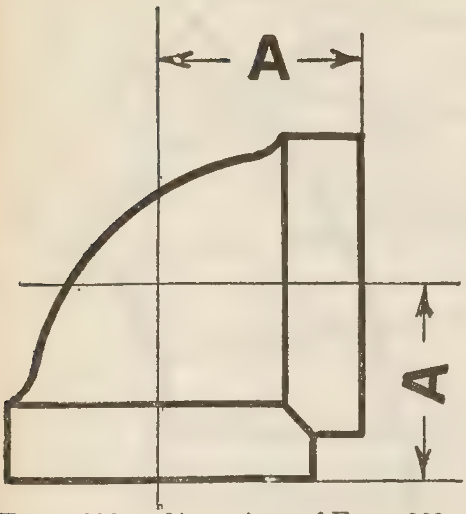


Figs. 8029 to 8032.—Comparison of standard and extra strong 3 and 4 in. wrought pipes.

Fittings such as TYs, crosses intended to connect with waste or soil lines from baths, closets, etc., have inlets tapped, pitched ¼-in. to the foot so that these lines will have proper pitch to drain.

The inlets on reducing fittings are always the smallest openings. The tables on the following pages give the dimensions of cast iron drainage fittings and will be found useful in laying out any Durham system installation.

DIMENSIONS FOR 90° ELBOWS.



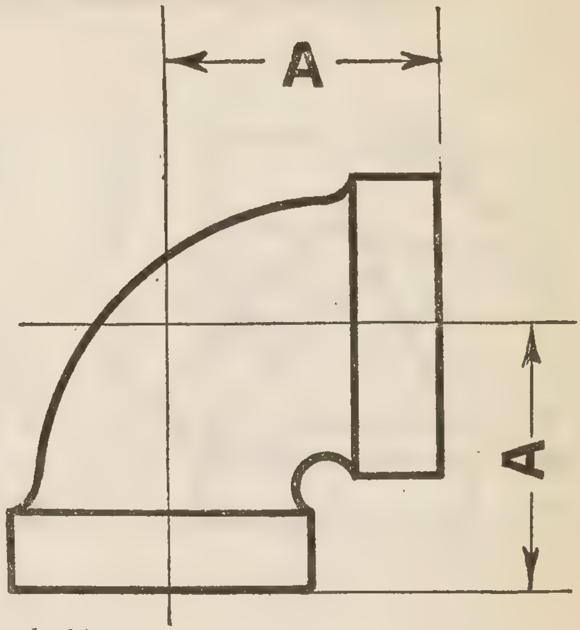


FIG. 8,033.—Dimensions of Essex 90° elbow, *short turn*.
FIG. 8,034.—Dimensions of Essex 90° elbow, *long turn*.

90° ELBOW, SHORT TURN

Size	A
1¼	1⅞
1½	2
1½ x 1¼	2
2	2⅝
2 x 1½	2⅛
2½	2 13/16
3	3⅜
4	3 15/16
5	4⅝
6	5 11/32
7	5 11/16
8	6½
10	7⅞
12	9

90° ELBOW, LONG TURN

Size	A
1¼	2⅜
1½	2 11/16
2	3 7/16
2½	3 11/16
3	5⅞
4	6¾
5	6⅛
6	8 7/16
7	9½
8	1⅞
10	12¼
12	13

DIMENSIONS FOR 45° ELBOWS.

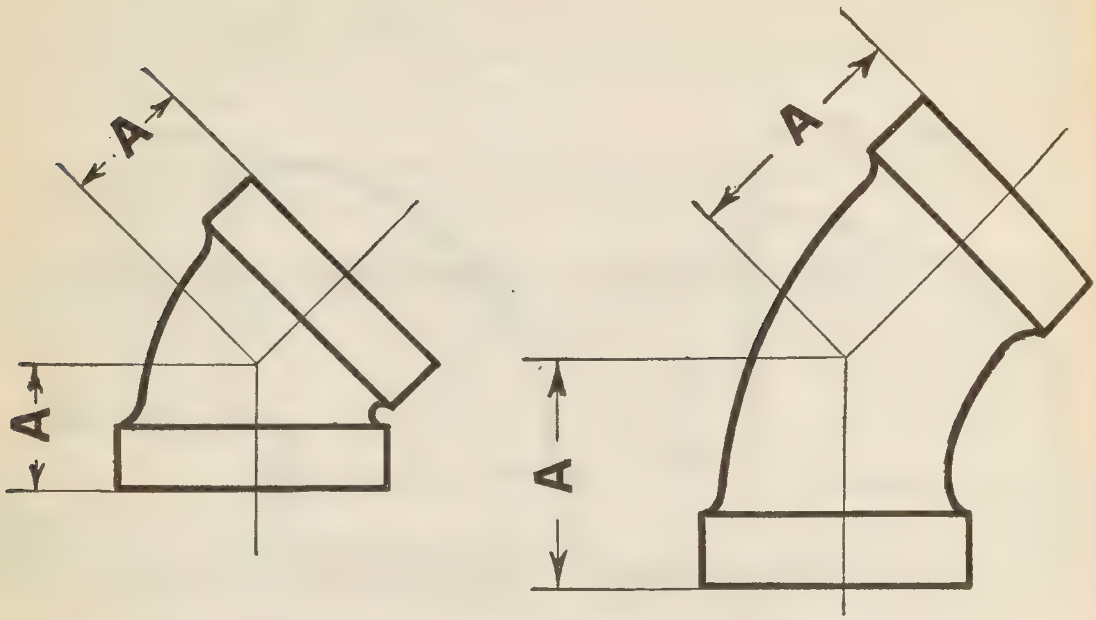


FIG. 8,035.—Dimensions of Essex 45° elbow, *short turn.*

FIGS 8,036.—Dimension of Essex 45° elbow *long turn.*

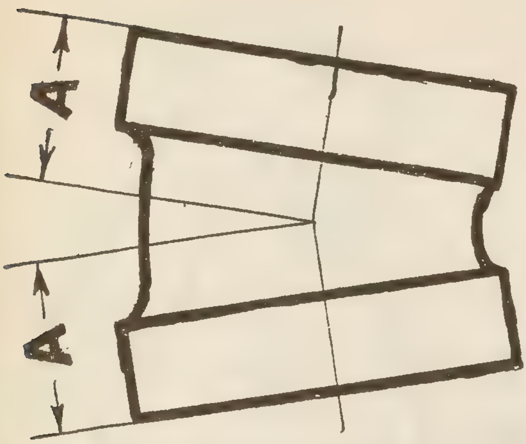
45° ELBOW, SHORT TURN

Size	A
1¼	1 5/16
1½	1½
2	1⅝
2½	1 11/16
3	2¼
4	2 7/16
5	2 11/16
6	3
7	3⅜
8	3½
10	4 7/16
12	5½

45° ELBOW, LONG TURN

Size	A
1¼	1¾
1½	1⅞
2	2¼
2½	3
3	4⅝
4	4⅝
5	5 7/16
6	6
7	6¼
8	6¾
10	7½
12	8¼

DIMENSIONS FOR 22½° AND 11¼° ELBOWS.



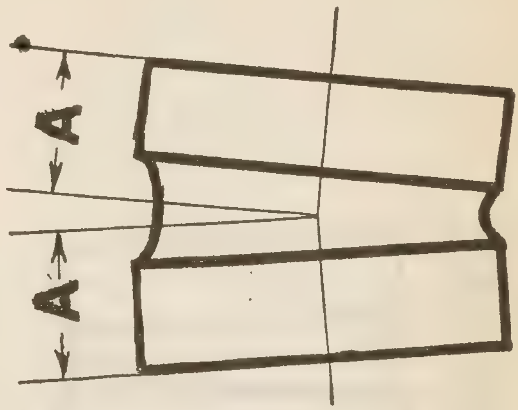


FIG. 8,037.—Dimensions of Essex 22½° elbow.

FIG. 8,038.—Dimensions of Essex 11¼° elbow.

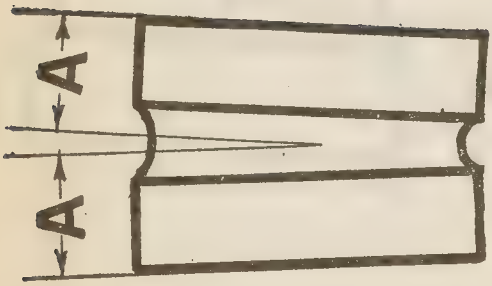
22½° ELBOW

Size	A
1¼	1 1/16
1½	1¼
2	1 7/16
2½	1½
3	1⅞
4	1⅞
5	2
6	2 3/16
7	2½
8	2⅞
10	3¾
12	4

11¼° ELBOW

Size	A
1¼	1 1/16
1½	1⅛
2	1⅜
2½	1 7/16
3	1⅝
4	1 11/16
5	1⅞
6	2
7	2 1/16
8	2⅛
10	3

DIMENSIONS FOR 5⅝° AND 60° ELBOWS.



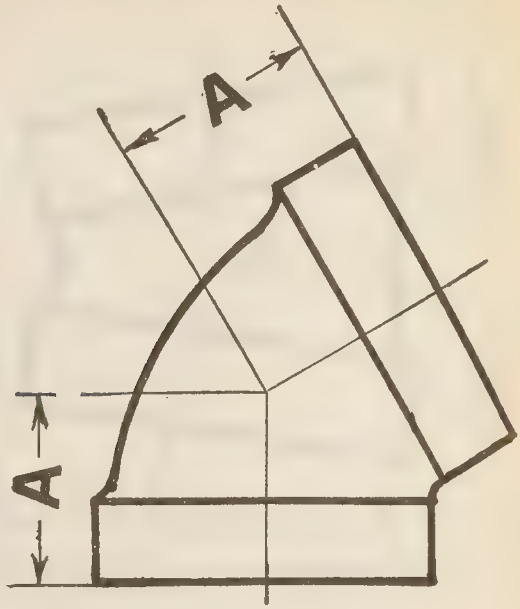


FIG. 8,039.—Dimensions of Essex 5⅝° elbow.

FIG. 8,040.—Dimensions of Essex 60° elbow.

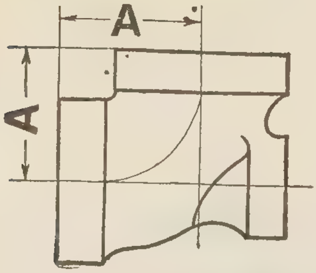
5⅝° ELBOW

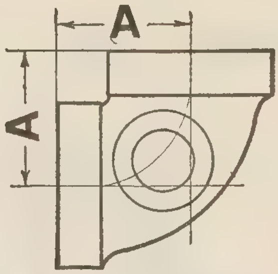
Size	A
1¼	1 1/16
1½	1⅛
2	1¼
2½	1½
3	1⅝
4	1 11/16
5	1¾
6	1⅞
7	1 15/16
8	2
10	2¼

60° ELBOW

Size	A
1¼	1½
1½	1½
2	1⅞
2½	2¼
3	2½
4	2⅞
5	3¼
6	3⅝
7	4
8	4¾
10	5¼

DIMENSIONS FOR SPECIAL ELBOWS





FIGS. 8,041 and 8,042.—Dimensions of Essex 90° elbows. Fig. 8,041, with heel outlet; fig. 8,042, with side outlet.

90° ELBOW, WITH HEEL OUTLET

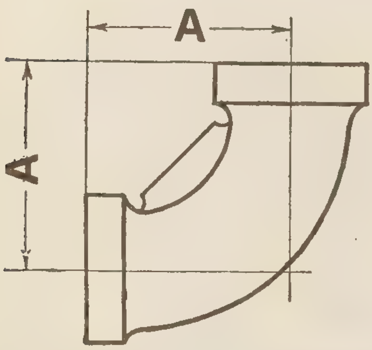
Size	A
4	$3\frac{15}{16}$

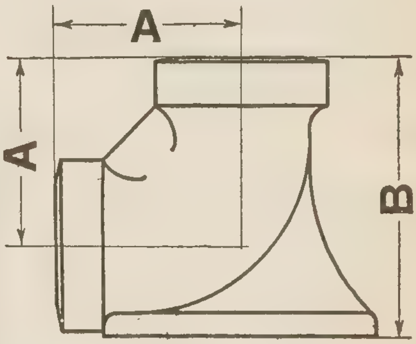
Size of outlet, 2″

90° ELBOW, WITH SIDE OUTLET

Size	A
4	$3\frac{15}{16}$

Size of outlet, 2″





FIGS. 8,043 and 8,044.—Dimensions of Essex 90° elbows; fig. 8,043, with cleanout; fig. 8,044, with base and cleanout.

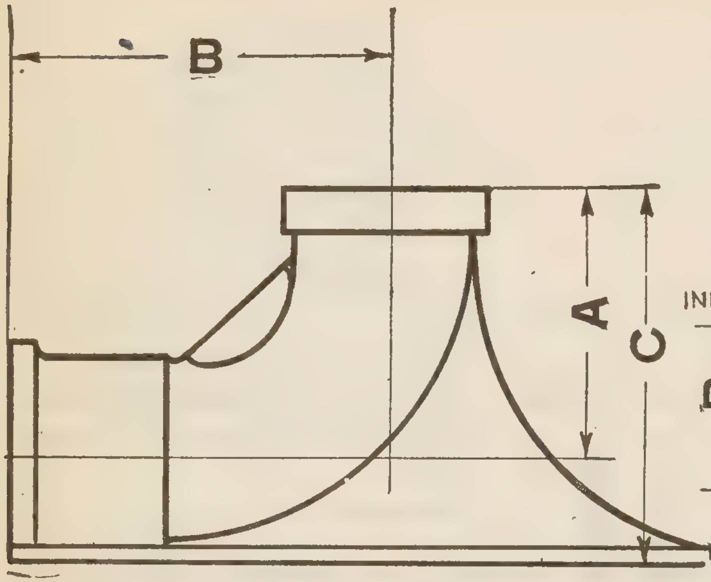
90° ELBOW, WITH CLEANOUT

Size	A
2	$3\frac{7}{16}$
3	$5\frac{7}{8}$
4	$6\frac{3}{4}$
5	$6\frac{1}{8}$
6	$8\frac{7}{16}$

90° BASE ELBOW, WITH CLEANOUT

Size	A	B
2	$3\frac{7}{16}$	$5\frac{1}{8}$
3	$5\frac{7}{8}$	$8\frac{1}{8}$
4	$6\frac{3}{4}$	$9\frac{1}{2}$
5	$6\frac{1}{8}$	$9\frac{1}{2}$
6	$8\frac{7}{16}$	$12\frac{7}{16}$

DIMENSIONS FOR SPECIAL ELBOWS.



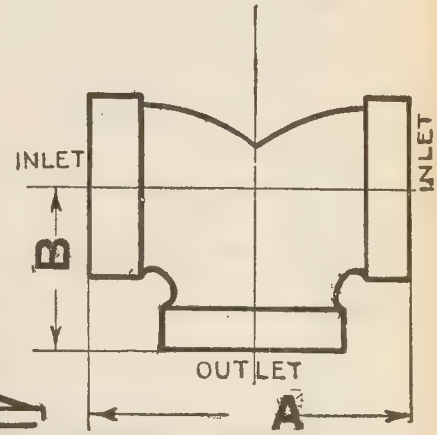


Fig. 8,045.—Dimensions of Essex 90° base elbow with cleanout and soil pipe hub connection.
Fig. 8,046.—Dimensions of Essex 3-way elbow.

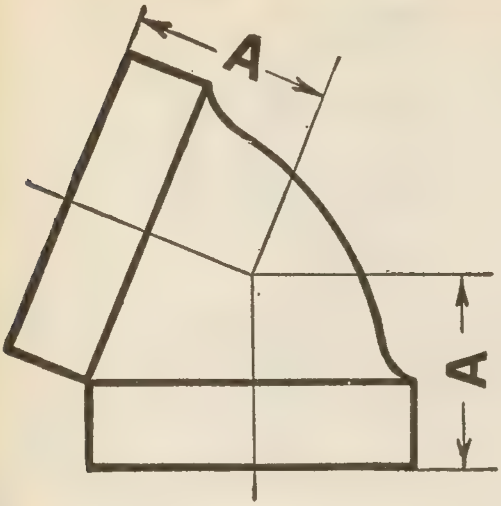
90° BASE ELBOW, WITH CLEAN-OUT AND SOIL PIPE HUB CONNECTION

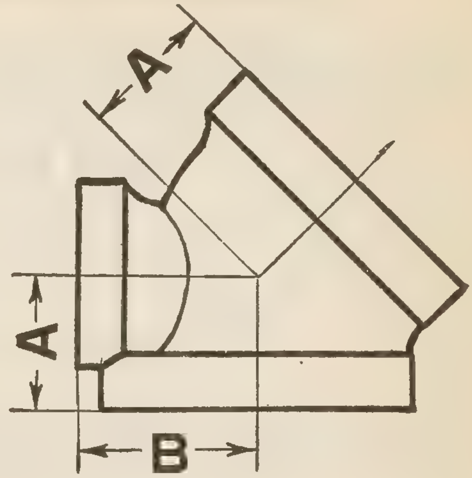
Size	A	B	C
3 x 2	$3\frac{7}{16}$	6¾	6½
3	5⅞	7	8⅛
4 x 3	5⅞	7½	8⅝
4	$6\frac{5}{16}$	7¾	9½
5 x 4	$6\frac{5}{16}$	9⅝	9¾
5	6⅛	9⅝	10
6 x 4	6¾	9⅝	10⅞
6 x 5	6⅛	9⅝	10½
6	8¼	9½	12¼
8 x 6	$8\frac{7}{16}$	10½	13¾
8	11⅞	14	17

3-WAY ELBOW

Size	A	B
1¼	4¾	2⅜
1½	5½	2¾
2	6¼	3⅛
2½	7⅜	$3\frac{11}{16}$
3	10¾	5⅜
4	14¾	7⅜
4 x 3	9½	$4\frac{5}{16}$
5	15	7½
5 x 4	11⅜	$5\frac{5}{16}$
6	16¼	8⅛
6 x 4	12⅜	$5\frac{7}{16}$
6 x 5	13⅜	6¼

DIMENSIONS FOR SPECIAL ELBOWS.





FIGS. 8,047 and 8,048.—Dimensions of Essex elbows. Fig. 8,047, 67½° elbow; fig. 8,048, 45° elbow with angle heel outlet.

67½° ELBOW

Size	A
1½	1⅞
4	3⅛

45° ELBOW, WITH ANGLE HEEL OUTLET

Size	A	B
4	2 7/16	3¼

Size of outlet, 2″

45° ELBOW, WITH SHOE

Size	A
2	1⅝
3	2¼
4	2 7/16
5	2 11/16
6	3
8	3½
10	4 7/16

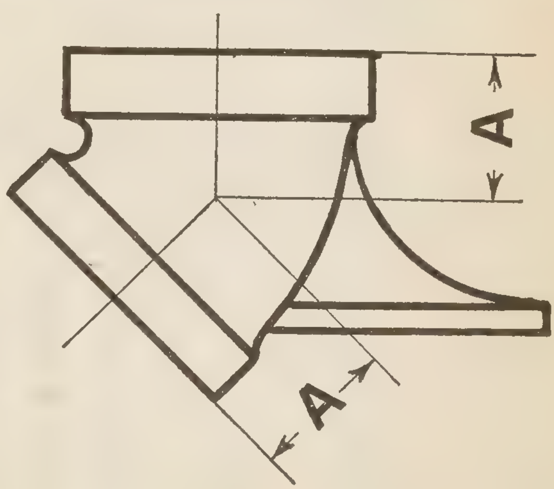
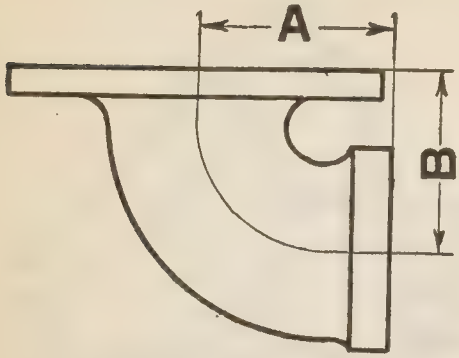
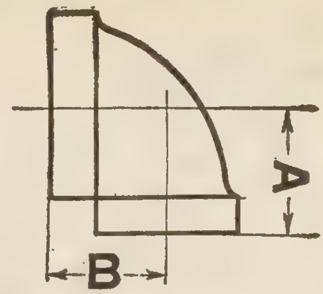


FIG. 8,049—Dimensions of Essex 45° elbow with shoe.

DIMENSIONS FOR CLOSET ELBOWS.





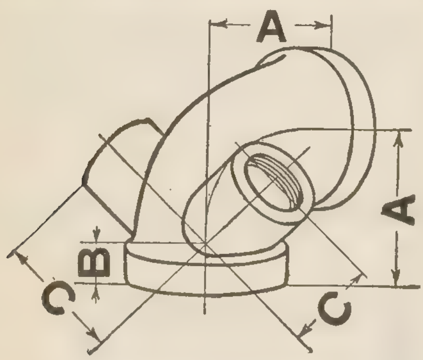
FIGS. 8,050 and 8,051.—Dimensions of Essex closet elbows. Fig. 8,050, with flange, 9″ flange on 3″ fitting; 10″ flange on 4″ fitting, fig. 8,051, reducing.

CLOSET ELBOW, WITH FLANGE

Size	A	B
3	5⅞	4⅝
4	6¾	5½

REDUCING CLOSET ELBOW

Size	A	B
5 x 4	$4\frac{7}{16}$	$3\frac{13}{16}$



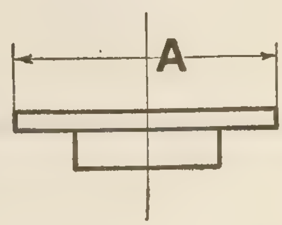


FIG. 8,052.—Dimensions of Essex 90° elbow with angle inlets on both sides, size of inlets, 2″
FIG. 8,053.—Dimensions of Essex closet flange.

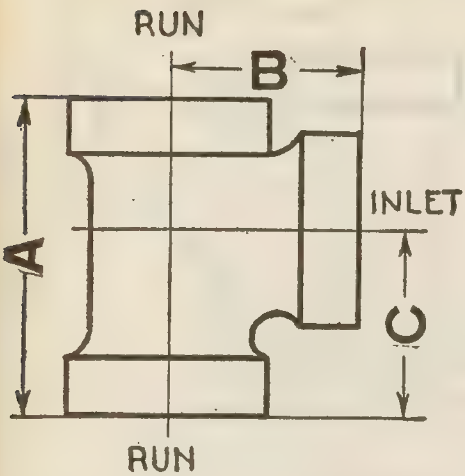
LONG TURN 90° ELBOW, WITH ANGLE INLETS ON BOTH SIDES

Size	A	B	C
3	5⅞	1½	4⅞
4	6¾	1⅝	5⅜
5	6⅛	1¾	6½
6	$8\frac{7}{16}$	1⅞	7½

CLOSET FLANGE

Size	A
4 x 7	7
4 x 10	10

DIMENSIONS FOR TYs.



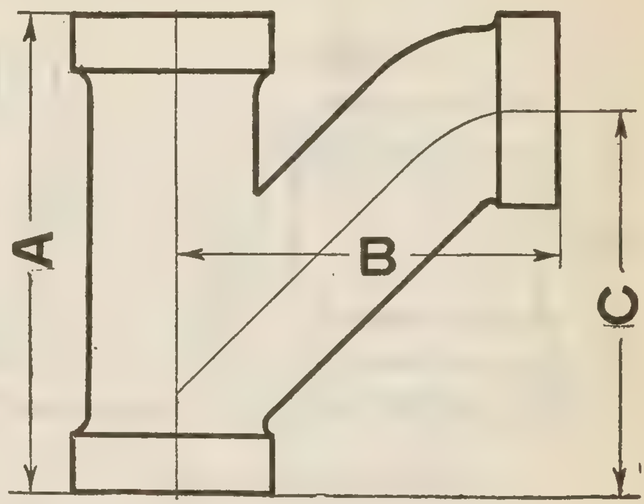


FIG. 8,054.—Dimensions of Essex *short* TY.

FIG. 8,055.—Dimensions of Essex *long* TY.

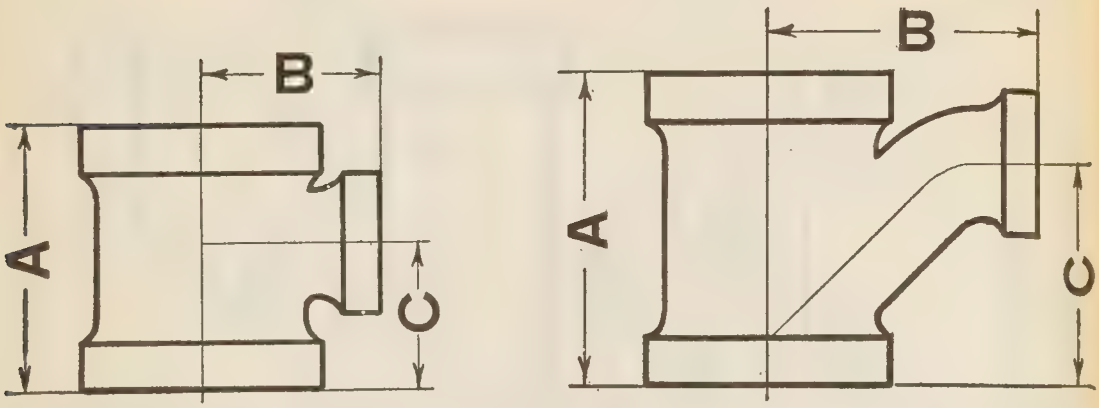
SHORT TY

Size	A	B	C
1¼	3 13/16	2 3/16	2 3/16
1½	4 5/16	2½	2 7/16
2	5¾	3 3/16	3 3/16
2½	6⅝	3⅞	3¾
3	7¼	4 3/16	4 3/16
4	9⅛	5⅜	5⅝
5	10¼	6 3/16	6 3/16
6	12	7⅛	7⅛
7	13¾	8⅝	8½
8	15¼	9⅛	9 5/16
10	19½	12¼	12¼

LONG TY

Size	A	B	C
1¼	4¾	3⅝	3 7/16
1½	5 7/16	4 3/16	3⅞
2	6½	5⅛	4⅝
2½	8¼	6 3/16	6 1/16
3	9	7⅛	6½
4	10¾	8⅞	7⅝
5	13	10 3/16	9 5/16
6	14¼	10¾	10¼
7	16	12⅛	11¼
8	17 7/16	13¼	11⅝
10	22¾	16 7/16	15⅜
12	26⅝	19	20

DIMENSIONS FOR REDUCING 45° TYs.



Figs. 8,056 and 8,057.—Dimension of Essex reducing TY's, Fig. 8,056, *short*; fig. 8,057 *long*.

REDUCING SHORT TY

Size	A	B	C
1½ x 1¼	4¼	$2\frac{11}{16}$	$2\frac{11}{16}$
2 x 1¼	$4\frac{7}{16}$	$2\frac{13}{16}$	$2\frac{11}{16}$
2 x 1½	$4\frac{15}{16}$	3	2⅞
2 x 2½	6½	3½	3⅝
2½ x 1¼	4⅜	$2\frac{15}{16}$	2½
2½ x 1½	5⅛	3¼	3
2½ x 2	5½	$3\frac{11}{16}$	3⅛
3 x 1½	$5\frac{1}{16}$	$3\frac{5}{16}$	$2\frac{11}{16}$
3 x 2	5¾	3⅝	3¼
4 x 1½	5¼	$3\frac{13}{16}$	3
4 x 2	6	4¼	$3\frac{7}{16}$
4 x 2½	6⅝	$4\frac{7}{16}$	$3\frac{13}{16}$
4 x 3	7⅜	$4\frac{15}{16}$	4⅛
5 x 1½	$5\frac{9}{16}$	4⅜	$3\frac{3}{16}$
5 x 2	6⅛	4½	$3\frac{11}{16}$
5 x 3	7¾	$5\frac{3}{16}$	4½
5 x 4	9¼	$5\frac{13}{16}$	5¼
6 x 2	$6\frac{5}{16}$	5¼	$3\frac{11}{16}$
6 x 3	7⅞	5¾	$4\frac{9}{16}$
6 x 4	9¼	$5\frac{15}{16}$	$5\frac{7}{16}$
6 x 5	10⅜	$5\frac{15}{16}$	$5\frac{15}{16}$
7 x 4	$10\frac{3}{16}$	$7\frac{5}{16}$	6¼
8 x 3	9⅞	7¼	6⅜
8 x 4	11⅝	7⅝	7½
8 x 5	12⅜	7⅞	7¾
8 x 6	12¾	$8\frac{1}{16}$	8⅜
8 x 7	15	9	9
10 x 4	$10\frac{13}{16}$	8¾	6⅝
10 x 6	13⅜	$9\frac{11}{16}$	8⅜
10 x 8	15⅞	10	9¾
12 x 4	15	9½	10½
12 x 5	15	9½	10

REDUCING LONG TY

Size	A	B	C
1½ x 1¼	5⅛	3⅞	4⅛
2 x 1½	$5\frac{13}{16}$	4½	4½
2½ x 1½	5¾	4½	4¼
2½ x 2	5⅜	4½	4⅜
3 x 1½	5⅞	5¼	$4\frac{9}{16}$
3 x 2	6⅝	5½	4½
4 x 1½	6⅛	$5\frac{7}{16}$	4¾
4 x 2	7	6⅜	5⅛
4 x 2½	8⅝	$7\frac{1}{16}$	6⅝
4 x 3	9¼	7¾	6½
5 x 1½	$6\frac{5}{16}$	6	$4\frac{15}{16}$
5 x 2	7⅜	$6\frac{11}{16}$	5⅝
5 x 3	9½	$8\frac{7}{16}$	7
5 x 4	11⅛	$9\frac{7}{16}$	$7\frac{15}{16}$
6 x 2	6½	6¾	$4\frac{7}{16}$
6 x 3	$8\frac{15}{16}$	$7\frac{3}{16}$	6¼
6 x 4	11¼	$9\frac{13}{16}$	8¼
6 x 5	13	$10\frac{11}{16}$	$9\frac{7}{16}$
7 x 3	10¼	9½	7¼
7 x 4	10¼	9⅝	7
8 x 3	8¾	9¼	5⅞
8 x 4	10⅝	10	7¼
8 x 5	13¾	10⅝	8¼
8 x 6	14¼	10¾	8¾
10 x 4	14	13	11
10 x 6	16⅛	14⅛	11⅝
10 x 8	17⅜	11¼	11⅛
12 x 4	17	15½	13
12 x 5	17	15½	13

DIMENSIONS FOR 45° Ys.

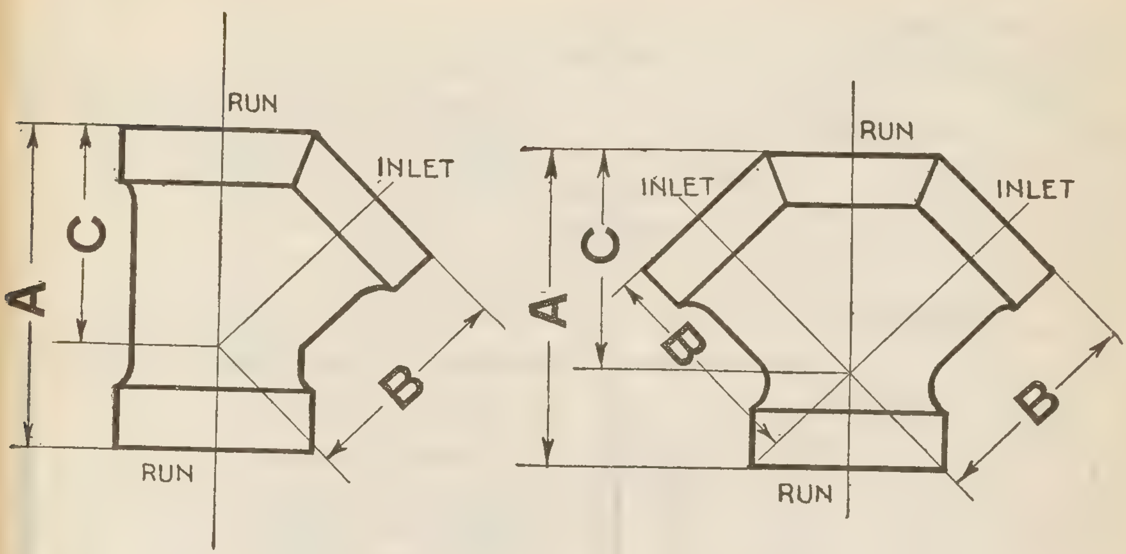


FIG. 8,058.—Dimensions of Essex 45° Y.

FIG. 8,059.—Dimensions of Essex double 45° Y.

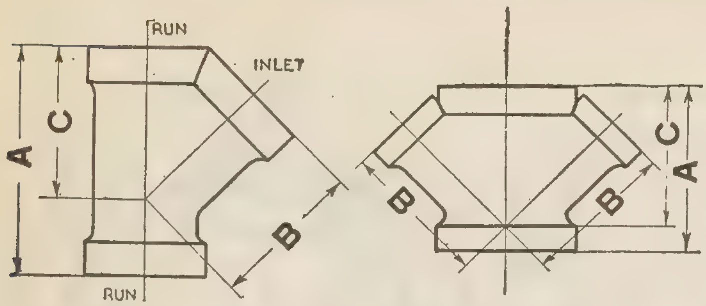
45° Y

Size	A	B	C
1	4	2 11/16	2 11/16
1¼	5 3/16	3 7/16	3 7/16
1½	5¼	3 7/16	3 7/16
2	6¼	4⅛	4⅛
2½	8	5¼	5¼
3	8⅜	6	6
4	9⅝	7	7
5	11⅜	8⅜	8⅜
6	13¼	10	10
7	15¼	11¼	11¼
8	16½	12⅜	12⅜
10	20¼	15¼	15¼
12	24¼	19⅝	19⅝

DOUBLE 45° Y

Size	A	B	C
1¼	5 3/16	3 7/16	3 7/16
1½	5¼	3 7/16	3 7/16
2	6¼	4⅛	4⅛
2½	8	5¼	5¼
3	8⅜	6	6
4	9⅝	7	7
5	11⅜	8⅜	8⅜
6	13¼	10	10
7	15¼	11¼	11¼
8	16½	12⅜	12⅜
10	20¼	15¼	15¼
12	24¼	19⅝	19⅝

DIMENSIONS FOR REDUCING 45° Ys.



FIGS. 8,060 and 8,061.—Dimensions of Essex reducing 45° Y's. Fig. 8,060, single; fig. 8,061, double.

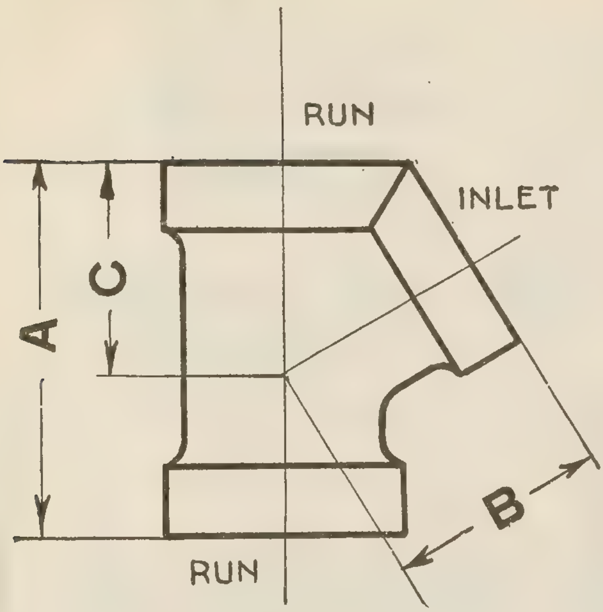
REDUCING 45° Y

Size	A	B	C
1½ x 1¼	5¼	3 7/16	3 7/16
2 x 1½	5 15/16	4¼	4¼
2½ x 1½	6¼	4⅝	4 9/16
2½ x 2	6⅜	4¾	4⅝
3 x 1½	6⅝	5 1/16	4 11/16
3 x 2	6¾	5¼	5⅛
3 x 2½	8	5 13/16	5 11/16
4 x 1½	7⅝	5⅝	5 7/16
4 x 2	6⅝	5⅞	5⅝
4 x 2½	7¼	5⅞	5¾
4 x 3	8½	6⅝	6⅜
5 x 2	7⅛	6¾	6
5 x 3	8¾	7½	7⅛
5 x 4	10 5/16	8	7⅞
6 x 2	7	7½	6⅝
6 x 3	8 13/16	8¼	7½
6 x 4	10½	9	8⅞
6 x 5	11½	9⅛	9
7 x 3	10	9⅝	8⅞
7 x 4	10¼	10½	9⅝
7 x 5	13½	10½	10½
7 x 6	15⅜	11 9/16	11⅜
8 x 3	9	10	8⅞
8 x 4	10⅜	10	8⅞
8 x 5	11⅜	10⅝	9¾
8 x 6	14	12	11½
8 x 7	16⅜	12 7/16	12 7/16
10 x 4	11⅞	12⅝	11⅝
10 x 5	13¾	12¾	12
10 x 6	13⅞	13⅝	13
10 x 7	17¼	14	14
10 x 8	17½	14⅜	14⅜
12 x 4	15	13⅜	11⅜
12 x 5	15	14	12¼
12 x 6	15	14⅝	13¼

REDUCING DOUBLE 45° Y

Size	A	B	C
1½ x 1¼	5¼	3 7/16	3 7/16
2 x 1½	5 15/16	4¼	4¼
2½ x 1½	6¼	4⅝	4 9/16
2½ x 2	6⅜	4¾	4⅝
3 x 1½	6⅝	5 1/16	4 11/16
3 x 2	6¾	5¼	5⅛
4 x 2	6⅝	5⅞	5⅝
4 x 3	8½	6⅝	6⅜
5 x 2	7⅛	6¾	6
5 x 3	8¾	7½	7⅛
5 x 4	10 5/16	8	7⅞
6 x 2	7	7½	6⅝
6 x 3	8 13/16	8¼	7½
6 x 4	10½	9	8⅞
6 x 5	11½	9⅛	9
7 x 4	10¼	10½	9⅝
7 x 5	13½	10½	10½
7 x 6	15⅜	11 9/16	11⅜
8 x 3	9	10	8⅞
8 x 4	10⅜	10	8⅞
8 x 5	11⅜	10⅝	9¾
8 x 6	14⅛	12 5/16	11 13/16
8 x 7	16⅜	12 7/16	12 7/16
10 x 4	11⅞	12⅝	11⅝
10 x 5	13¾	12¾	12
10 x 6	13⅞	13⅝	13
10 x 7	17¼	14	14
10 x 8	17½	14⅜	14⅜

DIMENSIONS FOR 60° Ys AND Ts.



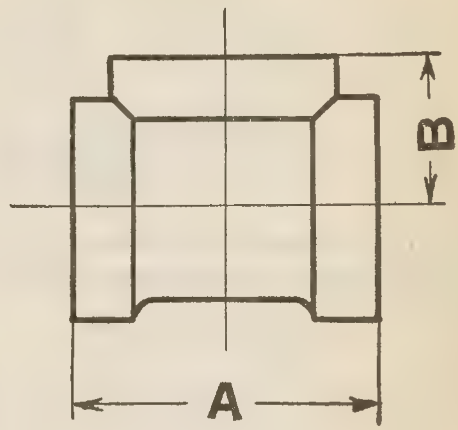


FIG. 8,062.—Dimensions of Essex 60° Y.
FIG. 8,063.—Dimensions of Essex T. Inlet tapped pitched ¼-in. to the foot.

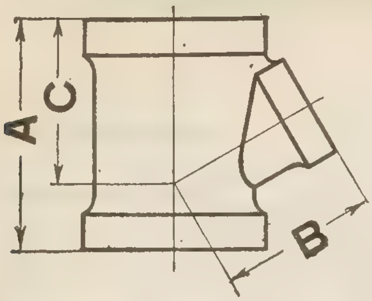
60° Y

Size	A	B	C
1¼	4⅞	2¾	2¾
1½	5¼	3 1/16	2⅞
2	6¼	3⅜	3¾
2½	6½	4⅛	4⅛
3	7¼	4⅞	4⅞
4	8 7/16	6	5¾
5	10¼	7	7
6	11⅝	7⅞	7⅞
8	16½	10¾	10¾

TEE

Size	A	B
1¼	3¾	1⅞
1½	4⅛	2
2	5⅛	2½
2½	5⅛	2 9/16
3	6⅜	3¼
4	8	4⅛
5	9⅛	4 9/16
6	10⅜	5 3/16
7	11⅝	5 13/16
8	13	6 7/16
10	15	7½
12	18	9

DIMENSIONS FOR REDUCING 60° Ys AND Ts.



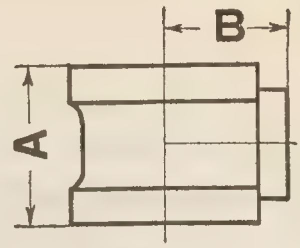


FIG. 8,064.—Dimensions of Essex reducing 60° Y.

FIG. 8,065.—Dimensions of Essex reducing T. Inlet tapped, pitched ¼-in. to the foot.

REDUCING 60° Y

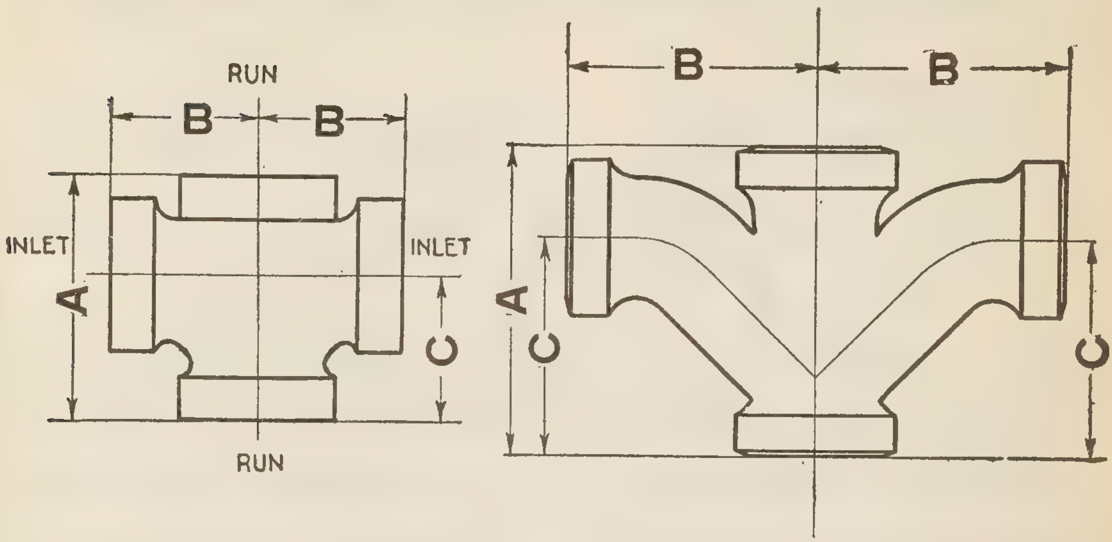
Size	A	B	C
1½ x 1¼	4¾	2⅞	2⅞
2 x 1½	6¼	2 7/16	3¾
2½ x 1½	6⅝	4¼	4¼
2½ x 2	6⅞	4⅜	4⅜
3 x 1½	6⅜	4½	4 3/16
3 x 2	6 7/16	4⅛	3 15/16
4 x 1½	7 1/16	4⅝	5 1/16
4 x 2	7 1/16	4⅝	5 1/16
4 x 3	7¾	5½	5¼
5 x 2	7	5¾	4⅞
5 x 3	8½	6	5 9/16
5 x 4	9¼	7	7⅞
6 x 2	7½	6¼	6⅛
6 x 3	9¾	7¼	7
6 x 4	9¾	7¼	7
6 x 5	11	7½	7¾
7 x 4	10¾	8⅝	7 5/16
8 x 3	8¾	8	6½
8 x 4	9¾	8 11/16	7⅜
8 x 5	12⅜	9⅜	8 7/16
8 x 6	12⅜	9⅜	8 7/16
8 x 7	14⅝	10	10

REDUCING TEE

Size	A	B
1½ x 1¼	3⅞	1 15/16
2 x 1½	4⅜	2½
2½ x 1½	4½	2¾
2½ x 2	5 3/16	2¾
3 x 1½	5½	3⅛
3 x 2	5½	3⅛
4 x 2	4⅞	3⅝
4 x 3	6¾	3⅞
5 x 2	6⅞	4 7/16
5 x 3	6⅞	4 7/16
5 x 4	8⅛	4 9/16
6 x 2	8⅛	5⅛
6 x 3	8⅛	5⅛
6 x 4	8⅛	5⅛
6 x 5	9½	5 3/16
7 x 4	8 11/16	6
8 x 4	8 13/16	6
8 x 5	10	6
8 x 6	10¼	6
8 x 7	12¼	6¾
10 x 5	10 5/16	7½
10 x 6	11⅜	7 7/16
10 x 7	12⅝	7⅞
10 x 8	13⅝	8
12 x 8	15	9
12 x 10	16½	9

NOTE.—The inlets on reducing fittings are always the smallest openings.

DIMENSIONS FOR CROSSES



FIGS. 8,066 and 8,067.—Dimensions of Essex crosses. Fig. 8,066, *short*; fig. 8,067, *long*. The inlet of crosses are tapped pitched ¼-in. to the foot. These fittings are also made with one or more side outlets, straight or on an angle, on one or both sides.

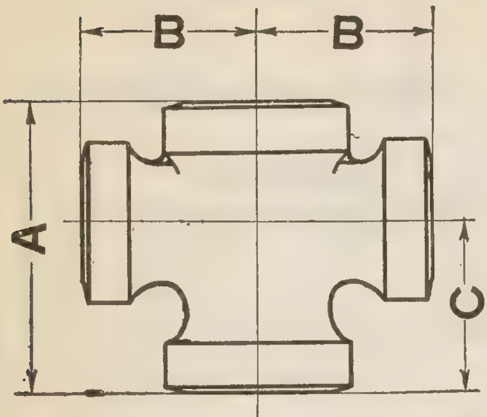
SHORT CROSS

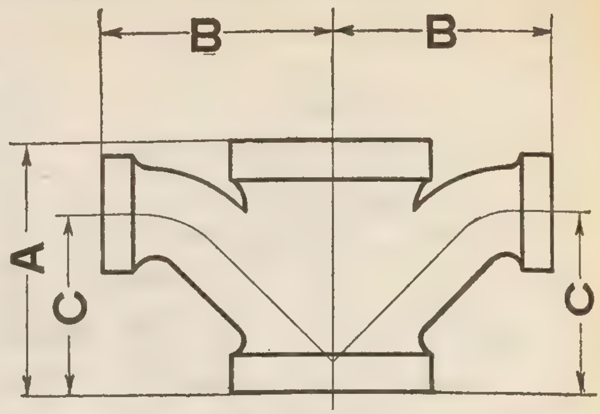
Size	A	B	C
1¼	3 13/16	2 3/16	2 3/16
1½	4 5/16	2½	2 7/16
2	5¾	3 3/16	3 3/16
2½	6⅝	3⅞	3¾
3	7¼	4 3/16	4 3/16
4	9⅛	5⅜	5⅝
5	10¼	6 3/16	6 3/16
6	12	7⅛	7⅛
7	13¾	8⅝	8½
8	15¼	9⅛	9 5/16
10	19½	12¼	12¼

LONG CROSS

Size	A	B	C
1¼	4¾	3⅝	3 7/16
1½	5 7/16	4 3/16	3⅞
2	6½	5⅛	4⅝
2½	8¼	6 3/16	6 1/16
3	9	7	6½
4	10¾	8⅝	7⅝
5	13	10 3/16	9 5/16
6	14¼	10¾	10¼
7	16	12⅛	11¼
8	17 7/16	13¼	11⅝
10	22¾	16 7/16	15⅜
12	26⅝	19	20

DIMENSIONS FOR REDUCING CROSSES





FIGS. 8,068 and 8,069.—Dimensions of Essex reducing crosses. Fig. 8,068, *short;* fig. 8,069, *long.* The inlets are pitched ¼ inch to the foot on reducing fittings and are always the smallest openings.

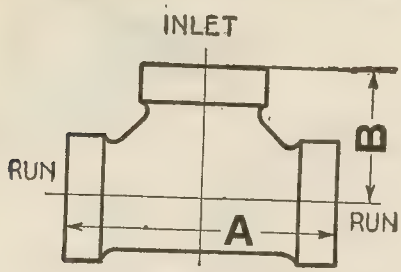
REDUCING SHORT CROSS

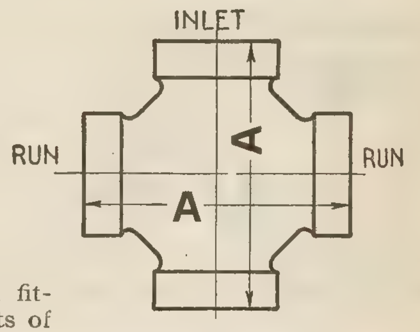
Size	A	B	C
1½ x 1¼	4⅜	2¾	2¾
2 x 1¼	4 7/16	2 13/16	2 11/16
2 x 1½	4 15/16	3	2⅞
2½ x 1½	5½	3 11/16	3⅛
2½ x 2	5½	3 11/16	3⅛
3 x 1½	5 1/16	3 5/16	2 15/16
3 x 2	5¾	3⅝	3¼
4 x 2	6	4¼	3 7/16
4 x 3	7⅜	4 15/16	4⅛
5 x 2	6⅛	4½	3 11/16
5 x 3	7¾	5 3/16	4½
5 x 4	9¼	5 13/16	5¼
6 x 2	6¼	5⅛	3⅝
6 x 3	7⅞	5¾	4 9/16
6 x 4	9¼	5 15/16	5 7/16
6 x 5	10⅜	5 15/16	5 15/16
7 x 4	10 3/16	7 5/16	6¼
8 x 3	9⅞	7¼	6⅜
8 x 4	11⅝	7⅝	7½
8 x 5	12⅜	7⅞	7¾
10 x 4	10 13/16	8¾	6⅝
10 x 6	13⅜	9 15/16	8⅜
10 x 8	15⅞	10	9¾

REDUCING LONG CROSS

Size	A	B	C
1½ x 1¼	5⅛	3⅞	4⅛
2 x 1½	6⅜	4 5/16	5
2½ x 1½	5¾	4½	4¼
2½ x 2	5⅜	4½	4⅜
3 x 1½	5⅞	5¼	4 9/16
3 x 2	6⅝	5½	4½
4 x 2	7	6⅜	5⅛
4 x 3	9¼	7¾	6½
5 x 2	7⅜	6 11/16	5⅝
5 x 3	9½	8 7/16	7
5 x 4	11⅛	9 7/16	7 15/16
6 x 2	6½	6¾	4 7/16
6 x 3	8⅞	7¼	6¼
6 x 4	11¼	9 13/16	8¼
6 x 5	13	10 11/16	9 7/16
7 x 4	10¼	9½	7¼
8 x 3	8¾	9¼	5⅞
8 x 4	10⅝	10	7¼
8 x 5	13¾	10⅝	8¼
8 x 6	14¼	10¾	8¾
10 x 4	14	13	11
10 x 6	16⅛	14⅛	11⅝
10 x 8	18	14½	13

DIMENSIONS FOR MISCELLANEOUS FITTINGS.





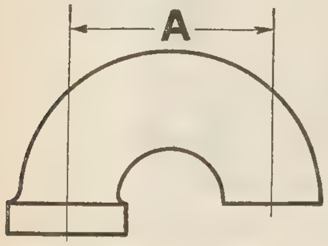
FIGS. 8,070 and 8,071.—Dimensions of Essex basin fittings. Fig. 8,070 T; fig. 8,071, cross. The inlets of these fittings are tapped pitched ¼-in. to the foot.

BASIN TEE

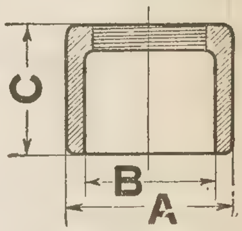
Size	A	B
1¼	4¾	2⅜
1½	5⅝	2¾
1½ x 1¼	5⅛	2$\frac{9}{16}$
2	7	3½
2 x 1½	6¾	3⅜
2½	8¼	4¼
2½ x 1¼	5¾	3½

BASIN CROSS

Size	A	B
1½	5⅝	5⅝
2	7	7
2 x 1½	6¾	6¾



FIGS. 8,072 and 8,073.—Dimension of Essex fittings. Fig. 8,072, air capping; fig. 8,073, roof connection.



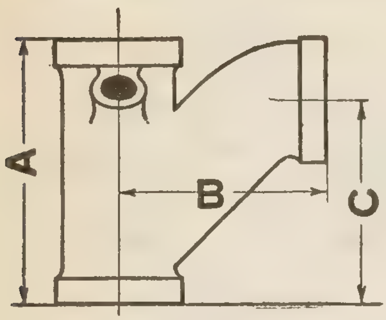
AIR CAPPING

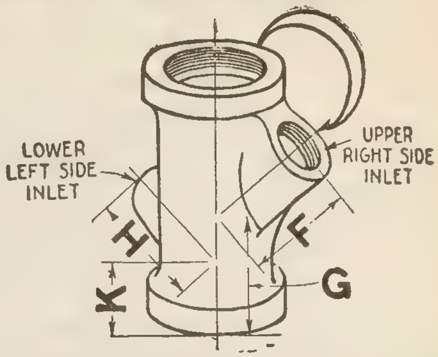
Size	A
2	5
3	5½
4	7
5	8

ROOF CONNECTION

Size	A	B	C
1½	2⅞	2¼	3
2	3½	3	3½
3	5	4¼	3¾
4	5⅞	5⅛	5
5	7⅜	6½	6
6.	8¼	7⅝	6⅞

DIMENSIONS FOR LONG TURN TY.

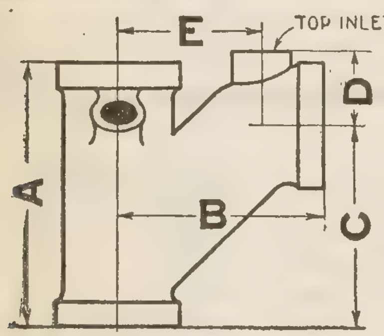


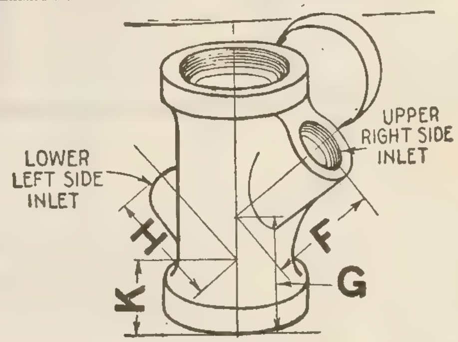


FIGS. 8,074 and 8,075.—Dimensions of Essex long turn TY (closet T) with either right or left side inlet.

LONG TURN TY (Closet Tee) with either Right or Left Side Inlet

Size	A	B	C	F	G	H	K
3	9	7⅛	6½	$4\frac{15}{16}$	3⅛	$4\frac{15}{16}$	$2\frac{5}{16}$
4	10¾	8⅞	7⅝	5¾	4⅜	5¾	1⅞
5 x 4	11⅛	$9\frac{7}{16}$	$7\frac{15}{16}$	6¼	3¾	6½	1⅝
6 x 4	11¼	$9\frac{3}{16}$	8¼	7¼	3½	7¼	1⅛





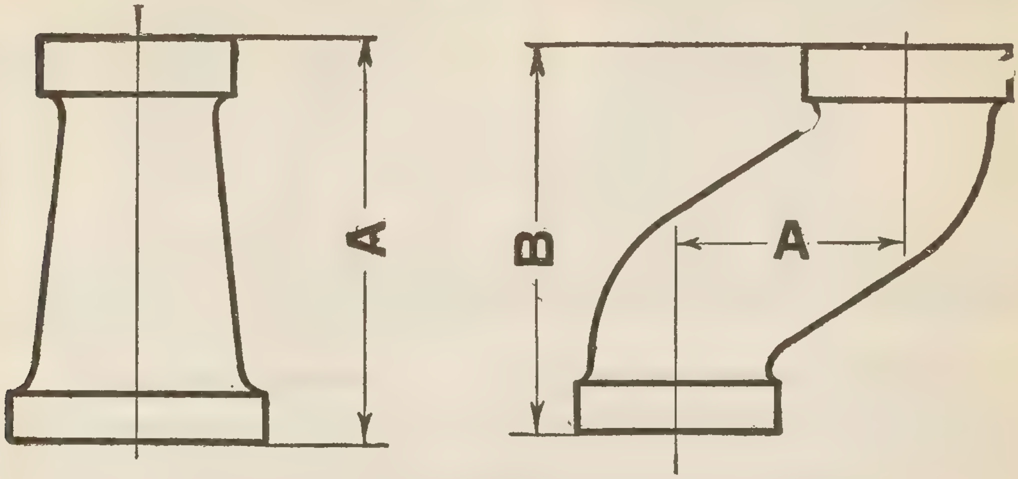
FIGS. 8,076 and 8,077.—Dimensions of Essex long turn TY (closet T) with either right or left side inlet and top inlet.

LONG TURN TY (Closet Tee) with either Right or Left Side Inlet and Top Inlet

Size	A	B	C	D	E	F	G	H	K
3	9	7⅛	6½	2¾	4⅛	$4\frac{15}{16}$	3⅛	$4\frac{15}{16}$	$2\frac{5}{16}$
4	10¾	8⅞	7⅝	3⅜	$5\frac{3}{16}$	5¾	4⅜	5¾	1⅞
5 x 4	11⅛	$9\frac{7}{16}$	$7\frac{15}{16}$	3⅜	$6\frac{3}{16}$	6¼	3¾	6½	1⅝
6 x 4	11¼	$9\frac{3}{16}$	8¼	3⅜	7⅛	7¼	3½	7¼	1⅛

NOTE.—The 90° inlet of closet T's is tapped pitched ¼-in. to the foot. Size of side and top inlets 2 ins.

DIMENSIONS FOR INCREASERS AND OFFSETS.



FIGS. 8,078 and 8,079.—Dimensions of Essex fittings. Fig. 8,078, increaser; fig. 8,079, offset.

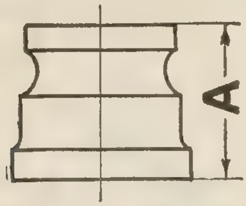
INCREASER

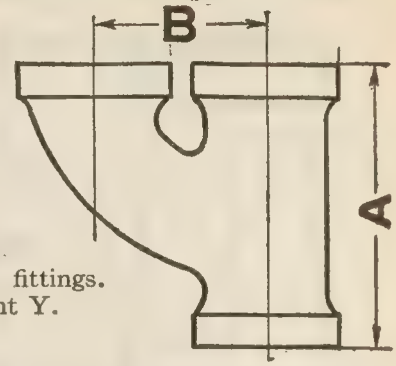
Size	A
2 x 1½	9
2½ x 2	9
3 x 2	9
3 x 2½	9
4 x 2	9
4 x 3	9
5 x 2	9
5 x 3	9
5 x 4	9
6 x 4	9
6 x 5	9
7 x 6	9
8 x 4	9
8 x 6	9
10 x 6	9
10 x 8	9
12 x 10	9

OFFSET

Size	To Offset	A	B
2	4	4	7½
2	6	6	10$\frac{7}{16}$
2	8	8	12$\frac{7}{16}$
2	10	10	14$\frac{7}{16}$
3	4	4	9¼
3	6	6	10½
3	8	8	13
3	10	10	14¾
3	12	12	17⅛
4	4	4	10⅛
4	6	6	11⅝
4	8	8	15⅜
4	10	10	16⅛
4	12	12	18⅛
5	6	6	13
5	8	8	15
5	10	10	17
5	12	12	19
6	6	6	13⅝
6	8	8	15⅛
6	10	10	17⅞
6	12	12	19⅞

DIMENSIONS FOR MISCELLANEOUS FITTINGS.





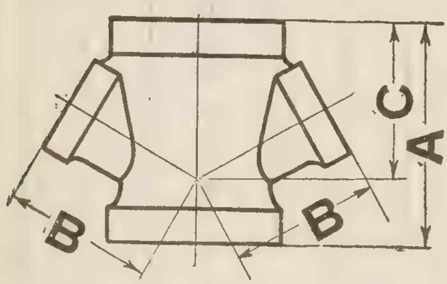
FIGS. 8,080 and 8,081.—Dimensions of Essex drainage fittings. Fig. 8,080, tucker connection; fig. 8,081, special upright Y.

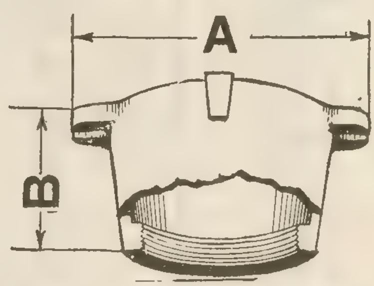
TUCKER CONNECTION

Size	A
2	3⅝
3	4⅝
4	6¼
5	6½
6	6 11/16
8	6 13/16
10	7⅛
12	9⅛

SPECIAL UPRIGHT Y

ize	A	B
1¼	6¼	3¼
1½	6 13/16	3⅝
2	6⅝	4
2 x 1½	6⅝	4
3	8¼	5 1/16
3 x 2	6¼	4
4	10¼	6⅜
4 x 2	6 11/16	4⅜





FIGS. 8,082 and 8,083.—Dimensions of Essex drainage fittings. Fig. 8.082, reducing 60° Y; fig. 8,083, sink coupling. The inlets on reducing fittings are always the smallest openings.

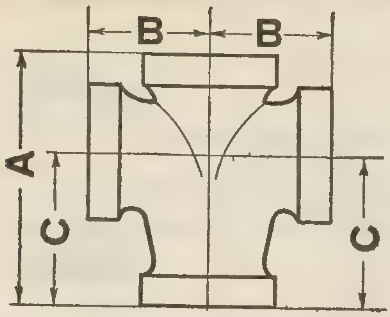
REDUCING DOUBLE 60° Y

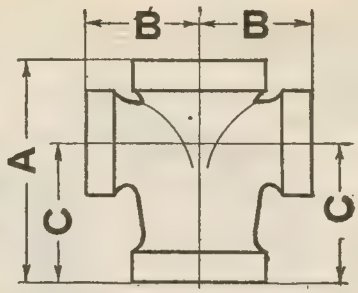
Size	A	B	C
2 x 1½	5 5/16	3¼	3¼

SINK COUPLING.

Size	A	B
1¼	4	2⅛
1½	4	2⅛
2	4	2⅛

DIMENSIONS FOR SPECIAL TYs.





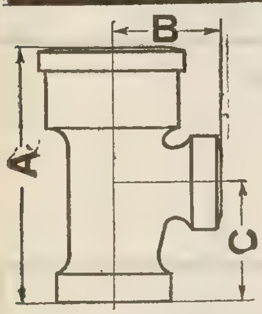
FIGS. 8,084 and 8,085.—Dimensions of Essex drainage fittings. Fig. 8,084, special double TY; fig. 8,085, special reducing double TY.

SPECIAL DOUBLE TY
Short Branch, Long Body, for Narrow Wall or Close Connection

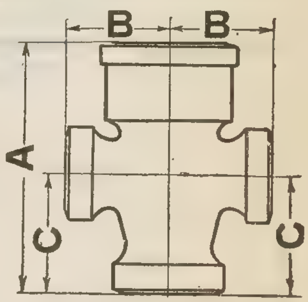
Size	A	B	C
1¼	$4\frac{13}{16}$	2¼	$2\frac{15}{16}$
1½	5⅜	2½	$3\frac{5}{16}$
2	6⅜	$3\frac{1}{16}$	$3\frac{11}{16}$
2½	$7\frac{3}{16}$	$3\frac{11}{16}$	$4\frac{7}{16}$
3	9	4⅜	5¾

SPECIAL REDUCING DOUBLE TY
Short Branch, Long Body, for Narrow Wall or Close Connection

Size	A	B	C
2 x 1½	5¾	3	3½
2½ x 1½	5¾	$3\frac{11}{32}$	$3\frac{13}{16}$
3 x 1½	6	3⅝	3⅝
3 x 2	7⅝	3¾	5



FIGS. 8,086 and 8,087.—Dimensions of Essex drainage fittings. Fig. 8,086 special TY; fig. 8,087, special double TY.



SPECIAL TY
With Hub for Soil or Wrought Iron Pipe Connection

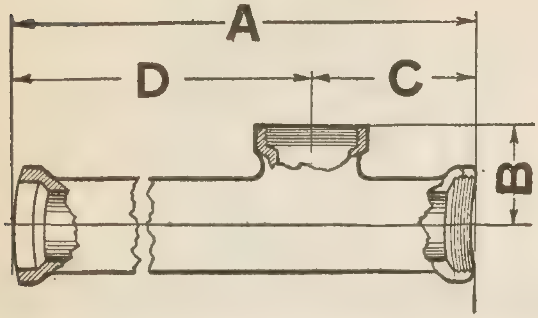
Hub End	Run	Br'ch	A	B	C
1½″ W.I.	1¼	1¼	5⅜	$2\frac{5}{16}$	$2\frac{5}{16}$
2″ W.I.	1½	1½	6¼	3⅜	3⅜
2″ Soil	1½	1½	7	3⅜	3⅜
2″ Soil	2	2	7½	$3\frac{13}{16}$	$3\frac{13}{16}$

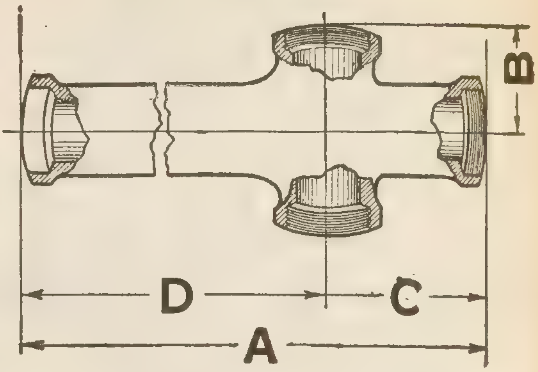
SPECIAL DOUBLE TY
With Hub for Soil or Wrought Iron Pipe Connection

Hub End	Run	Br'ch	A	B	C
2″ Soil	2	1½	7¼	3	3⅝

NOTE.—The inlets of TY's are tapped, pitched ¼-in. to the foot. The inlets on reducing fittings are always the smallest openings.

DIMENSIONS FOR SPECIAL TYs AND COUPLINGS.





FIGS. 8,088 and 8,089.—Dimensions of Essex fittings. Fig. 8,088, special long TY; fig. 8,089; special long double TY. Inlets tapped, pitched ¼-in. to the foot. The inlets on reducing fittings are always the smallest openings.

SPECIAL LONG TY

Size	A	B	C	D
1½	24	2½	4	20
1½	34	2½	4	30

SPECIAL LONG DOUBLE TY

Size	A	B	C	D
1½	24	2½	4	20
1½	34	2½	4	30

With 2″ spigot end for soil connection
Tapped Openings 1½″

COUPLING

Size	A
1¼	3
1½	3 7/16
2	3½
2½	4
3	4¼
4	4½
5	4¾
6	5¼
7	5½
8	5⅝
10	6¼

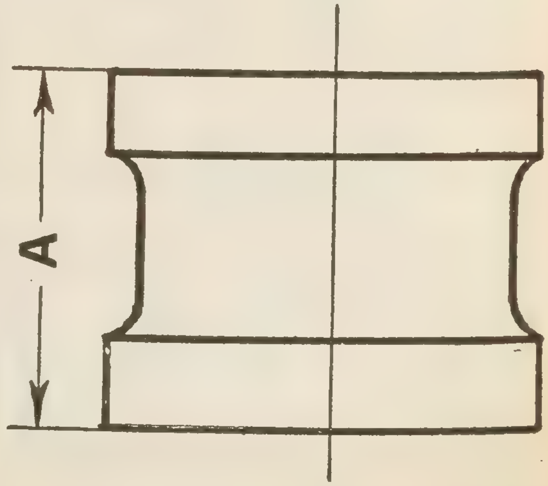
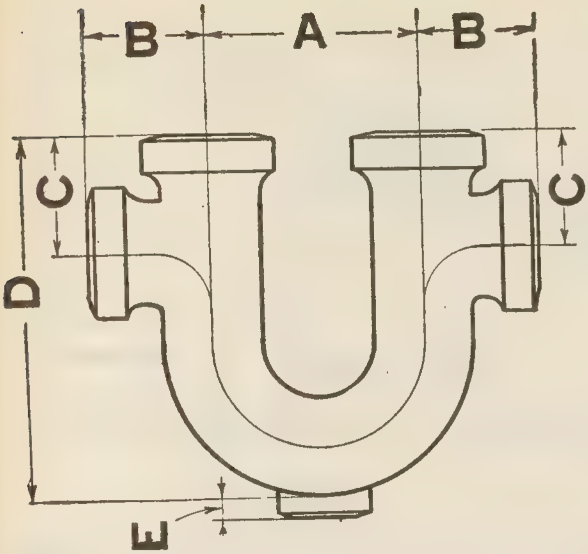


FIG. 8,090.—Dimensions of Essex couplings.

DIMENSIONS FOR TRAPS.



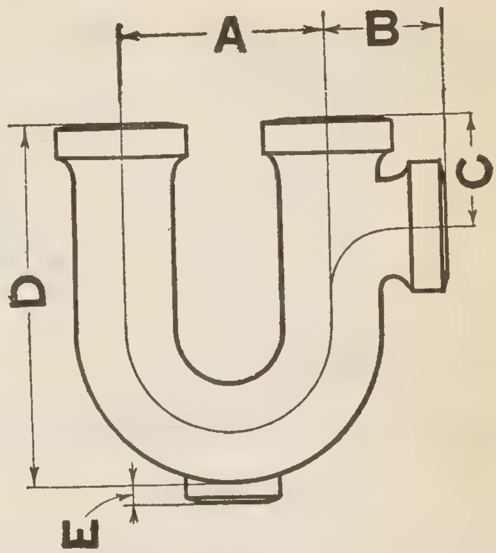


FIG. 8,091.—Dimensions of Essex running trap.

FIG. 8,092.—Dimensions of Essex ½ S trap.

RUNNING TRAP

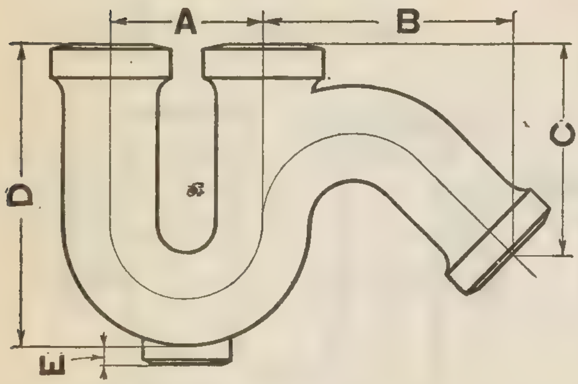
Size	A	B	C	D	E
1¼	3	2⅞	1⅞	5⅝	¼
1½	4	$3\frac{7}{16}$	$1\frac{15}{16}$	7	¼
2	4	$3\frac{1}{16}$	$2\frac{9}{16}$	7⅛	$\frac{7}{16}$
3	$6\frac{7}{16}$	3¾	3½	11½	¼
4	7½	5¼	4	13⅞	¼
5	$8\frac{7}{16}$	6	4¾	15⅞	¼
6	10	6¾	$5\frac{11}{16}$	19¼	¼
7	11¼	7¾	6⅛	21	¼
8	12⅜	9⅛	6⅝	23¾	¼
10	14¼	$10\frac{3}{16}$	7½	27¼	¼
12	16½	11½	8½	31¾	⅜

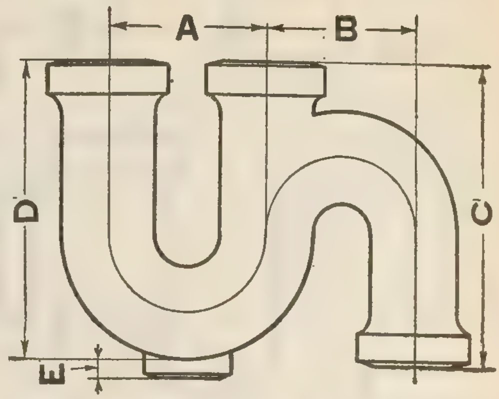
½ S TRAP

Size	A	B	C	D	E
1¼	3	2⅞	1⅞	5⅝	¼
1½	4	$3\frac{7}{16}$	$1\frac{15}{16}$	7	¼
2	4	$3\frac{1}{16}$	$2\frac{9}{16}$	7⅛	$\frac{7}{16}$
3	6½	3⅞	3½	11½	¼
4	7½	5¼	4	13¾	¼
5	8⅞	6¼	$4\frac{13}{16}$	16	¼
6	10⅛	7	5¾	$19\frac{1}{16}$	$\frac{7}{16}$
7	11¼	7¾	6⅛	21	¼
8	12⅜	9⅛	6⅝	23¾	¼
10	14¼	$10\frac{3}{16}$	7½	27¼	¼

NOTE.—The outlet of ½ S traps and the inlet and outlet of running traps are tapped pitched ¼-in. to the foot.

DIMENSIONS FOR TRAPS.





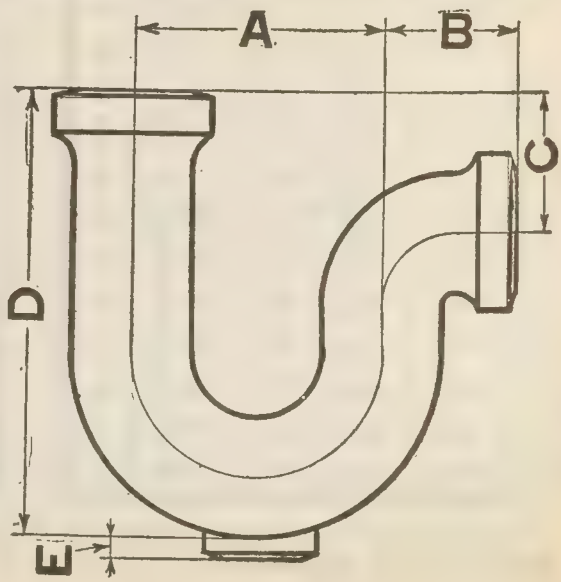
FIGS. 8,093 and 8,094.—Dimensions of Essex drainage fittings. Fig. 8,093, ¾ S trap; fig. 8,094 S trap.

¾ S TRAP

Size	A	B	C	D	E
1½	3	2¼	4	5⅜	⅜
2	$4\frac{1}{16}$	5⅝	5⅝	8⅛	⅜
3	6½	7¼	5⅝	11½	⅜
4	$7\frac{11}{16}$	8¼	6⅞	13⅝	¼
5	8⅜	11⅝	10¼	15¾	¼
6	10⅛	13⅞	11⅜	19⅛	¼

S TRAP

Size	A	B	C	D	E
1½	3	1⅞	5⅝	5⅜	⅜
2	4¼	$4\frac{1}{16}$	8⅛	8	⅜
3	$8\frac{3}{16}$	$2\frac{13}{16}$	11	10⅝	⅜
4	10⅛	$3\frac{5}{16}$	13¾	13	⅜
5	$12\frac{21}{32}$	$4\frac{7}{32}$	16⅞	15⅞	⅜
6	15	5	19¾	19¼	⅜



½ S TRAP, NO VENT

Size	A + B	C	D	E
1½	$7\frac{7}{16}$	$1\frac{15}{16}$	7	¼
2	8⅜	2⅝	9⅜	¼
3	10⅜	3½	11½	¼

FIG. 8,095.—Dimensions of Essex drainage fittings; ½ S trap, no vent. Outlet tapped, pitched ¼-in. to the foot.

DIMENSIONS FOR DRAINAGE FITTINGS.

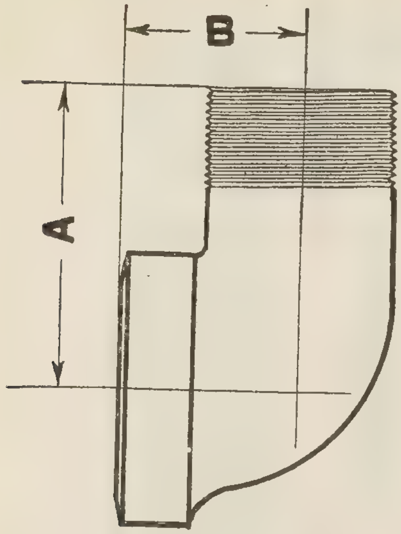


FIG. 8,096.—Dimensions of Essex 90° street elbow.

90° STREET ELBOW

Size	A	B
1¼	2⅝	1¾
1½	3	1 13/16
2	3	2¼

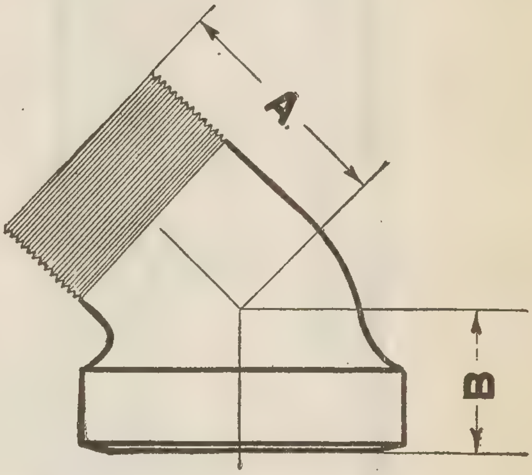
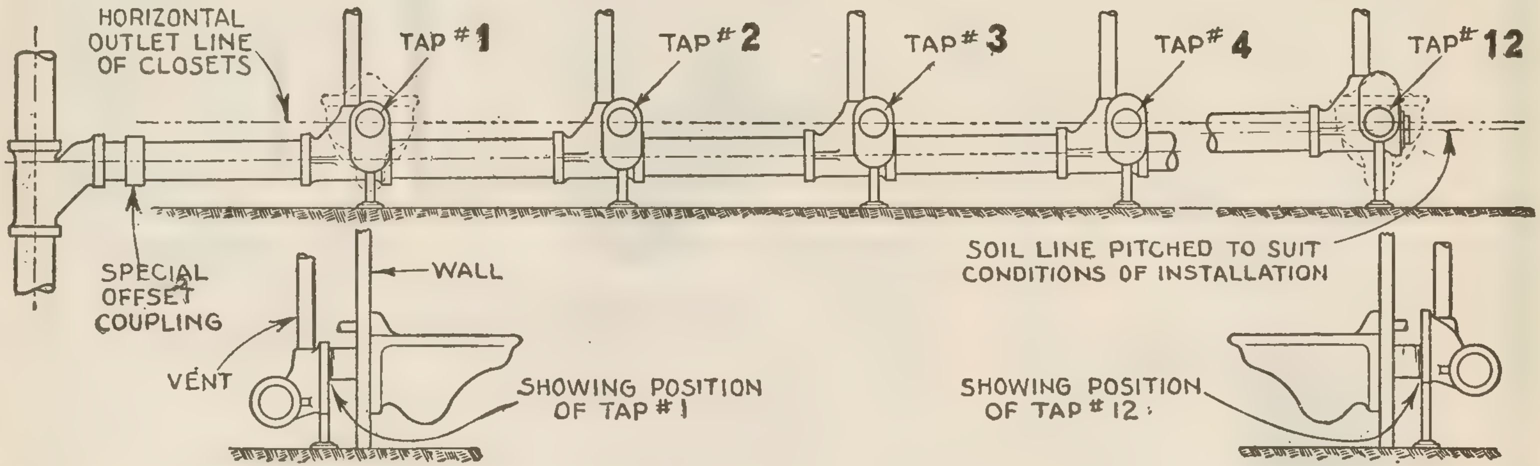


FIG. 8,097.—Dimensions of Essex 45° street elbow.

45° STREET ELBOW

Size	A	B
1¼	1¾	1 5/16
1½	2	1¼
2	2¼	1⅝

GENERAL ARRANGEMENT, SHOWING AN INSTALLATION OF A BATTERY OF CLOSETS



FIGS. 8,098 to 8,100.—Application of Crane drainage fittings for wall closets showing installation of a battery of closets. ***In installing*** the fitting with the highest tapping position should always be installed next to the soil stack. This fitting is marked No. 1. The second one from the stack is No. 2, and so on. The fitting with the lowest tapping position is No. 12. The different tapping positions are ⅜-in. from center to center. To get all closet seats the same distance from the floor level, also to take care of the pitch, of the soil line, a special pitched coupling is provided, which should preferably be used next to the stack. By turning this coupling, proper installation of the closet combinations is readily made possible.

Drainage Fittings for Wall Closets.—Special fittings may be obtained for use wherever back or wall outlet closets are installed in batteries. They are especially adaptable for buildings of reinforced concrete construction. Using these fittings in connection with wall hung closets eliminates the necessity of cutting and thus weakening the floors, as the horizontal waste line is entirely above the floor.

Before the advent of these fittings it was always necessary to suspend the horizontal waste line of a battery of closets from the ceiling below, unless a groove was made in the floor, or the floor of the toilet room raised. All of these methods are objectionable but are necessary where ordinary drainage fittings are used. As will be seen from the accompanying illustrations, these fittings are tapped for the closet connection at different distances from the center of the run, so that when the closets in a battery are set in line and the fittings placed in consecutive order according to the tapping numbers given them, the waste line is given a pitch.

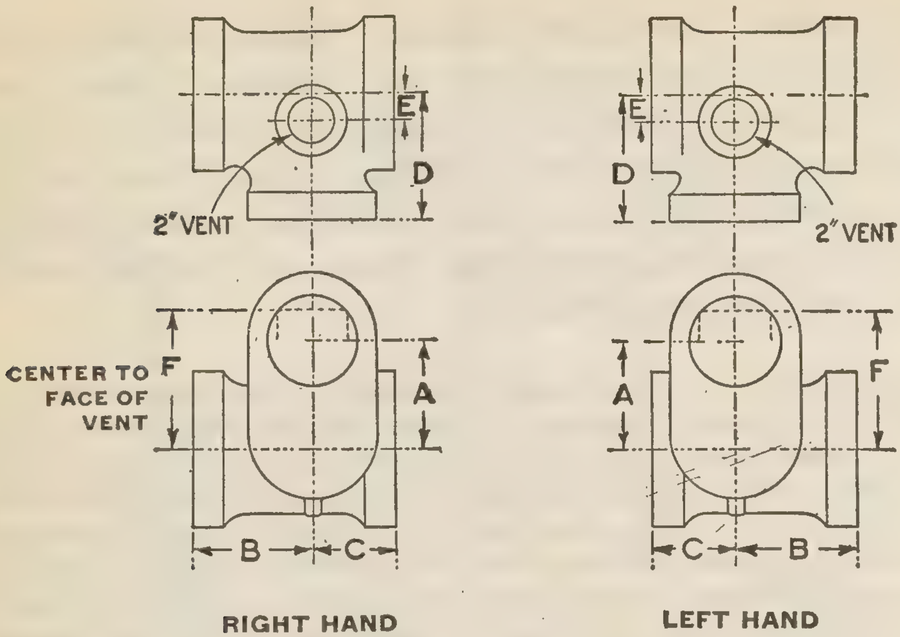
Each fitting takes the place of a drainage tee, nipple and Y (required where regular fittings are used) reducing the number of joints for each closet and simplifying the piping. The regular tapping shown in the dimension tables will take care of batteries up to twelve closets.

When six or less closets are installed in a single battery, it is recommended that fittings with the odd tapping numbers be specified, which will give the maximum amount of pitch. As an example, when fittings for six closets are required, the first fitting from the stack should be specified with "Tapping No. 1"; second, "Tapping No. 3"; third, "Tapping No. 5," etc. with "Tapping No. 11" for the sixth closet. The differences in the tapping dimensions will give additional pitch to the horizontal drainage waste line. For sanitary reasons, the long turn fittings should be used wherever possible.

The long turn fittings are made in the 4 × 4 and 4 × 5 in. sizes, either right or left hand and single or double.

The short turn fittings are made for use where the utility corridors are narrow and are also furnished in the 4 × 4 and 4 × 5 inch sizes, right or left hand, but in single pattern only.

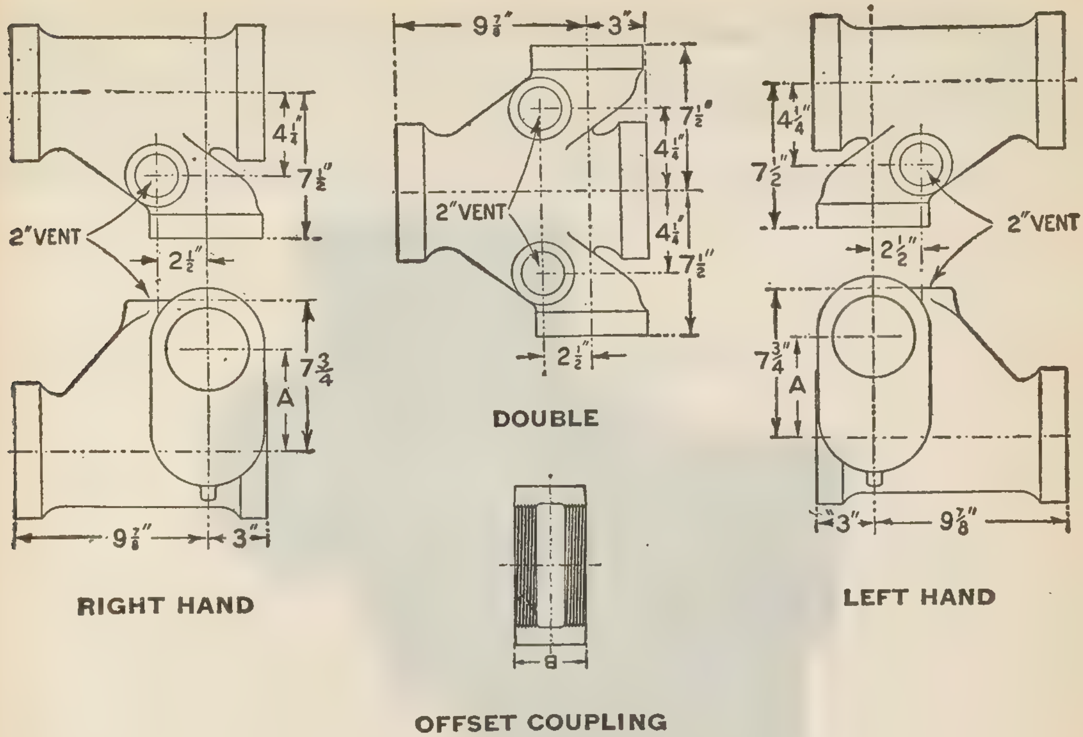
Facing inlet of fitting, if stack is to the left, the fittings are right hand, and if to the right, the fittings are left hand.



FIGS. 8,101 to 8,104.—Dimensions of Crane *short* turn Y *drainage* fitting for battery of closets with various tappings.

TAPPINGS AND DIMENSIONS

4x4							5x4						
Tapping No.	A In.	B In.	C In.	D In.	E In.	F Center to Face of Vent In.	Tapping No.	A In.	B In.	C In.	D In.	E In.	F Center to Face of Vent In.
1	2⅝	5¼	3½	5¼	0	3	1	4⅞	5⅜	3¾	5¾	1¼	6¼
2	2¼	5¼	3½	5¼	0	3	2	4½	5⅜	3¾	5¾	1¼	6¼
3	1⅞	5¼	3½	5¼	0	3	3	4⅛	5⅜	3¾	5¾	1¼	6¼
4	1½	5¼	3½	5¼	0	3	4	3¾	5⅜	3¾	5¾	1¼	6¼
5	1⅛	5¼	3½	5¼	0	3	5	3⅜	5⅜	3¾	5¾	1¼	6¼
6	¾	5¼	3½	5¼	0	3	6	3	5⅜	3¾	5¾	1¼	6¼
							7	2⅝	5⅜	3¾	5¾	1¼	6¼
							8	2¼	5⅜	3¾	5¾	1¼	6¼
							9	1⅞	5⅜	3¾	5¾	1¼	6¼
							10	1½	5⅜	3¾	5¾	1¼	6¼
							11	1⅛	5⅜	3¾	5¾	1¼	6¼
							12	¾	5⅜	3¾	5¾	1¼	6¼



FIGS. 8,105 to 8,110.—Dimensions of Crane long turn Y for battery of closets.

TAPPINGS

4"x4" and 5"x4"	
Tapping No.	Dimension A
1	5¼
2	4⅞
3	4½
4	4⅛
5	3¾
6	3⅜
7	3
8	2⅝
9	2¼
10	1⅞
11	1½
12	1⅛

Combined Soil and Packed Drainage Fittings.—This type of fitting is used extensively in California and other Western sections. Such fittings are designed to connect fixtures to soil pipes without the use of lead pipe and wiped joints. All of these

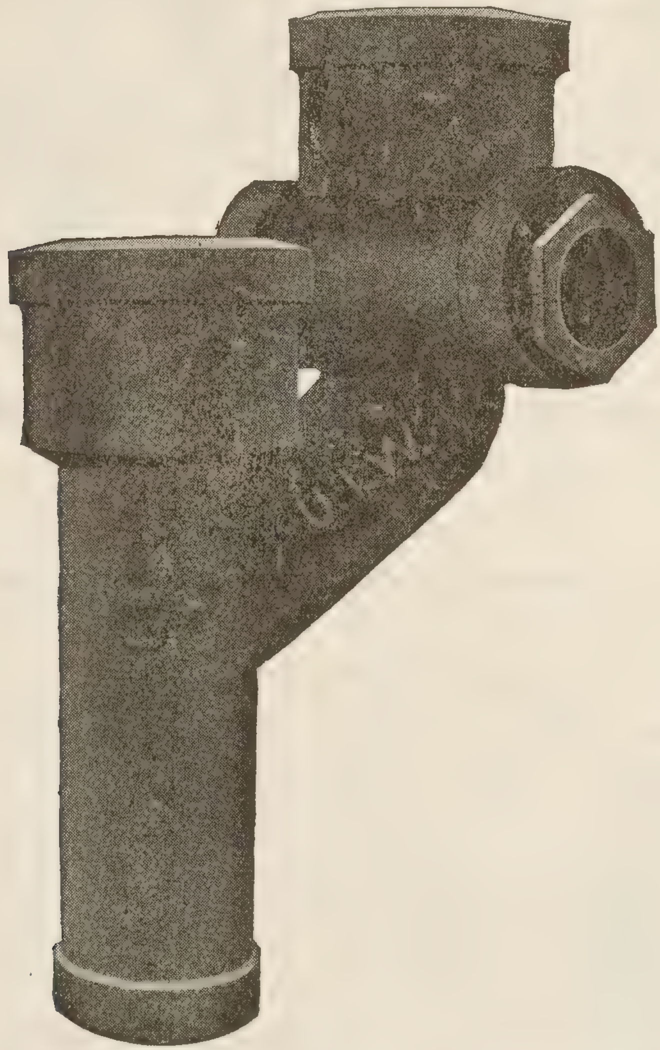


FIG. 8,111.—United Iron Works combined soil and packed drainage fitting; double combination TY with double bell.

fittings, as shown in figs. 8,111 to 8,113, have a blind washer secured by a brass gland (resting on a shoulder in the casting) threaded into the fitting receiving trap from waste.

As soon as they are caulked into the stack they are ready for pressure

test, not needing plug. When ready for finish, remove blind washer, insert trap through brass gland, place packing dipped in white lead around trap, tighten up gland, thus forming a packing or stuffing box which holds trap or pipe tight in its position as in fig. 8,118. The joint is designed to

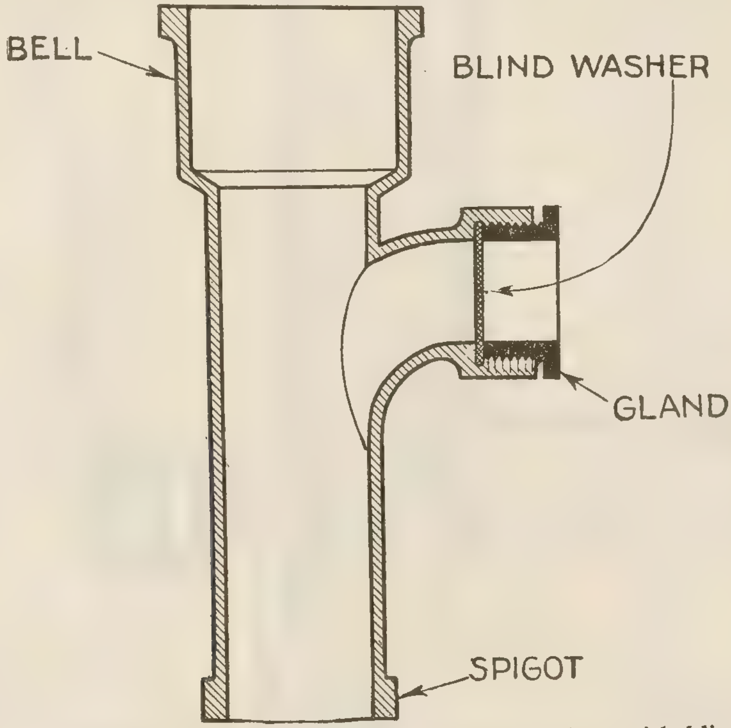


FIG. 8,112.—U. I. W. combined soil and packed drainage fittings with blind washer in position ready for test.

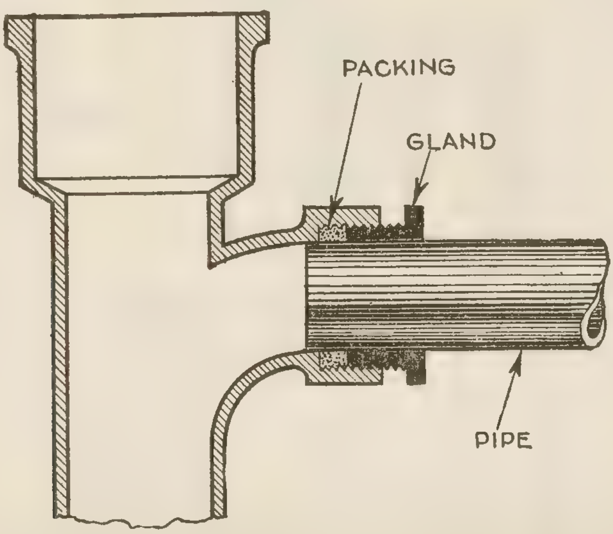


FIG. 8,113.—U. I. W. combined soil and packed drainage fitting with trap or other connecting pipe in position showing packing box joint.

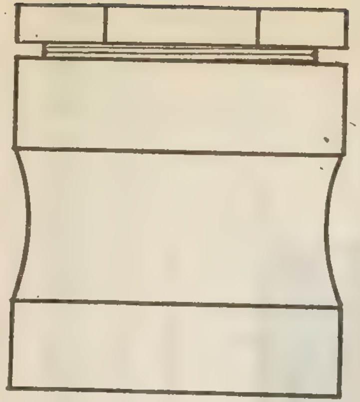
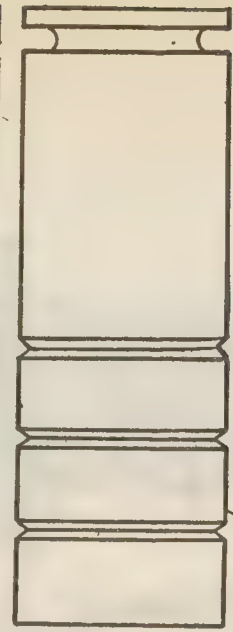


FIG. 8,114.—U. I. W. extension piece for extending basin or sink connection any distance from combined soil and packed drainage fittings.



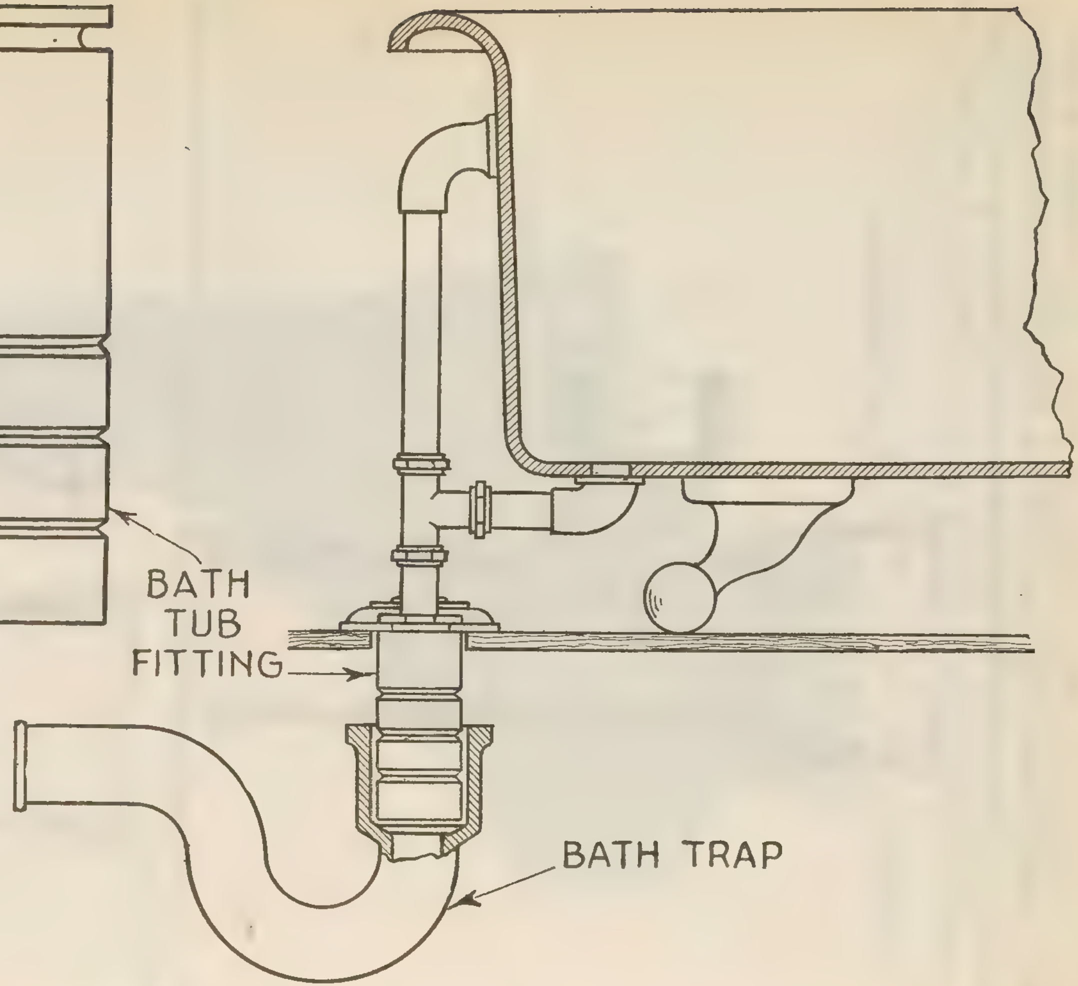
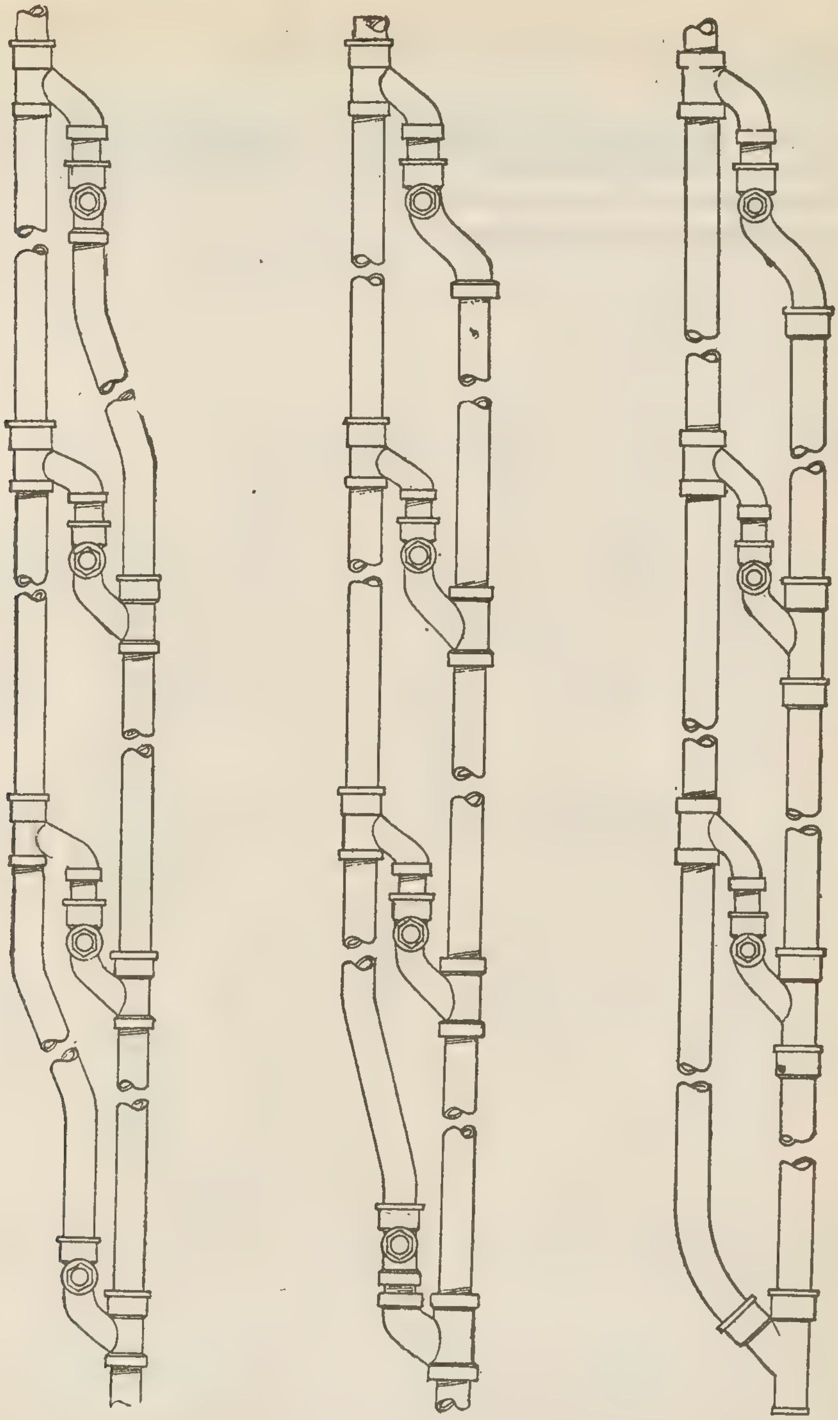


FIG. 8,115.—U. I. W. bath tub fitting. The fitting is adjusted to proper length by breaking off lower sections and then caulking into hub of trap below floor.

FIG. 8,116.—Application of U. I. W. bath tub fitting showing connection with trap and bath tub waste.



FIGS. 8,117 to 8,119.—Application of U. I. W. combination fittings to basin or sink stacks. These fittings go between the studding, therefore doing away with cutting, and taking up very little room. Inlets come flush with plaster and *n.p.* trap flange covers gland in fitting, making a perfect finish without special flanges.

stand a pressure of 200 lbs. per square inch. If desired the trap may be sweated to gland.

The inlet of fitting being tapped for iron pipe, extensions may be made with nipple and extension piece as shown in fig. 8,114. The different combinations that may be made from the full line of these fittings adapt them to all conditions that may arise.

CHAPTER 122

Boiler Fittings

There are certain fittings or devices, usually mounted on the boiler and which are essential for its proper operation. These devices consist of:

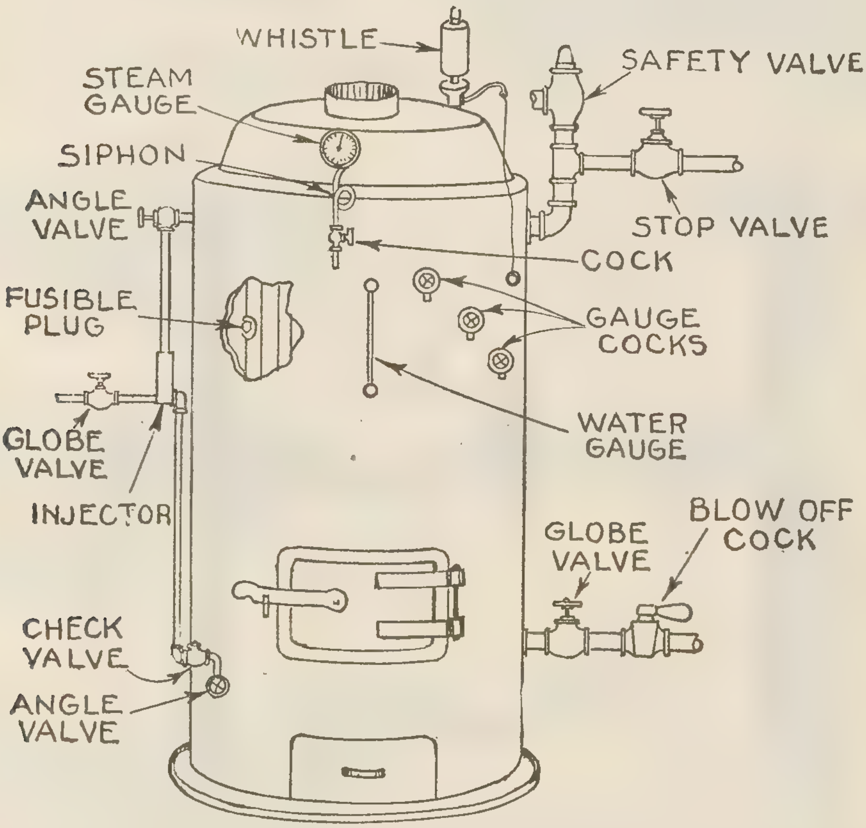
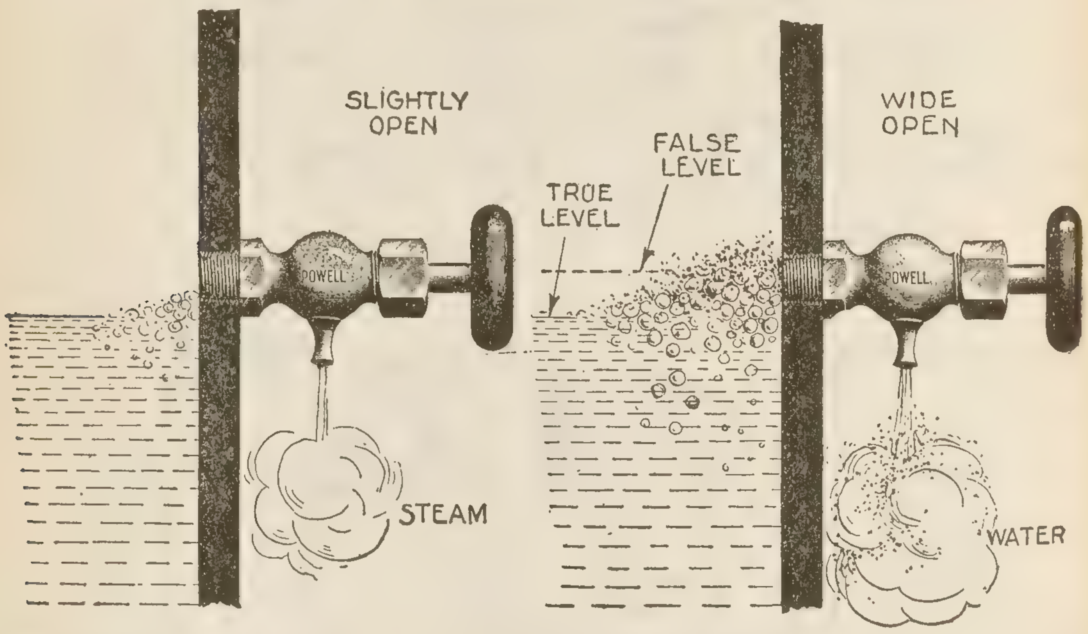


FIG. 8,120.—Vertical boiler showing the boiler fixtures consisting of control and indicating devices essential for safe operation. A portion of the shell is cut away to expose the fusible plug to view.

NOTE.—1, ***In connecting up a steam boiler*** it is necessary not to place any valves between safety valve and boiler, 2, that a stop valve must be placed on main steam line in case of battery of boilers; 3, that the injector must have an individual steam connection with no branches for other use; 4, that a globe valve is placed between check valve and boiler, allowing cleaning or repair of check valve while boiler is under steam; 5, that a globe (or gate) valve must be placed between check valve and boiler as a safeguard to prevent leakage, or in case blow off valve cannot be closed, or the valve becoming detached from its seat, and 6, that a drain cock should be put on safety valve connections.

1. Valves.
   a. Safety valve.
   b. Stop valve.
   c. Check valve.
   d. Blow off valve.
2. Water gauge cocks.
3. Water gauge.
4. Steam gauge.
5. Injector.
6. Fusible plug.
7. Separator.

Fig. 8,120 shows fixtures generally connected to a boiler. Of these, the various valves have been described in Guide No. 2, in the chapter on Valves, Faucets, and Cocks.



FIGS. 8,121 and 8,122.—Right and wrong way of testing water with gauge cocks. When the cock is only slightly opened, as in fig. 8,121, the water level is not materially raised by the outrushing steam, but if opened wide, as in fig. 8,122, the reduction of pressure inside and consequent violent ebulition to restore equilibrium causes a considerable disturbance of the water level near the cock, resulting in a false level as shown. *This precaution should be remembered*, especially when using the lower cock, because if opened wide, the water is lifted surprisingly high, hence, unless the lowest cock be at a liberal height above the crown sheet, it may when opened wide indicate water though the true level may be dangerously low.

Water Gauge Cocks.—It is of first importance that those in charge of a boiler shall know with certainty the height of the

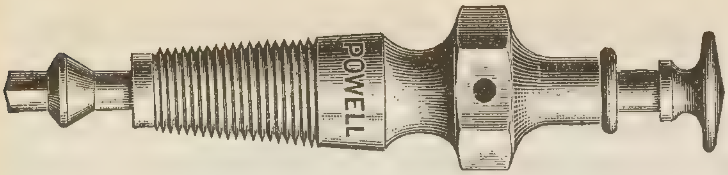
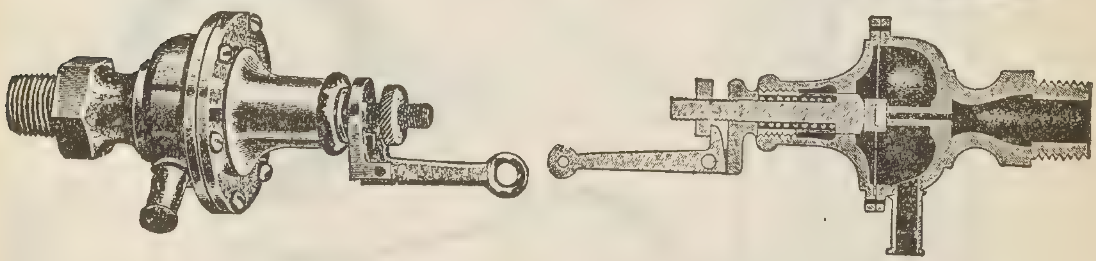
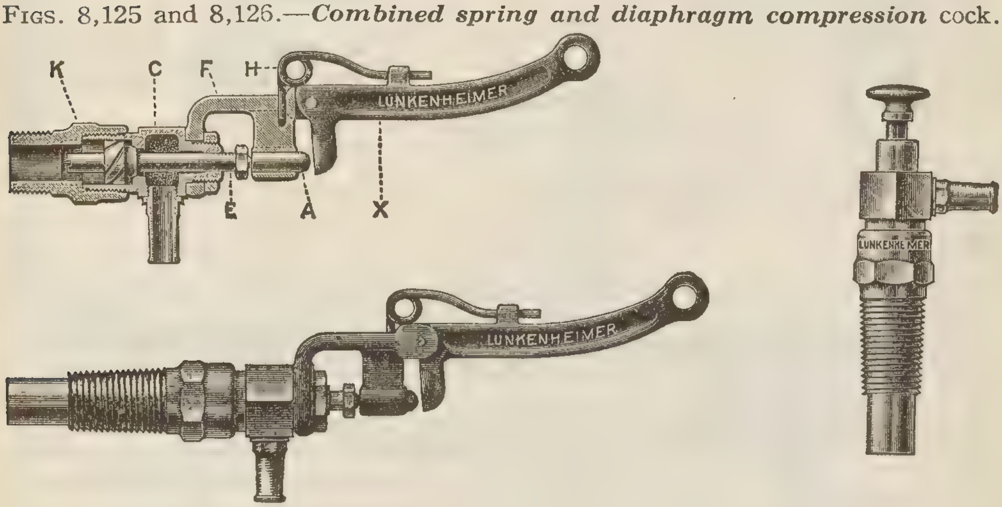


Fig. 8,123.—*Spring* cock; long shank push button or "Mississippi" pattern.

Fig. 8,124. — *Compression* cock; short shank, weighted lever or "ball" pattern.



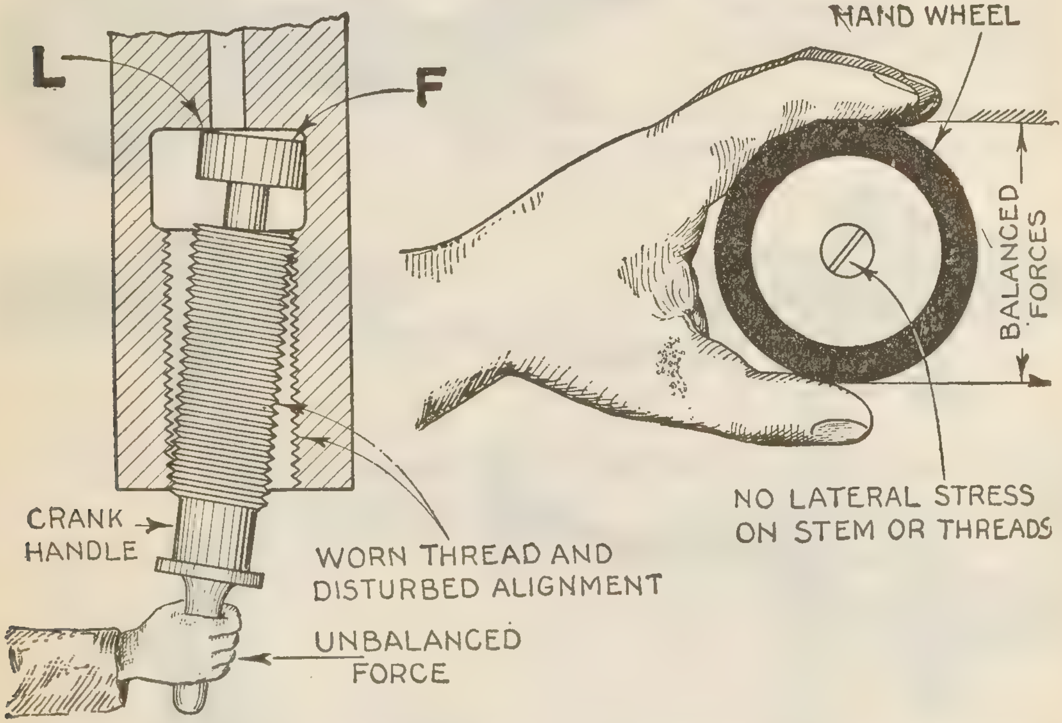
Figs. 8,125 and 8,126.—*Combined spring and diaphragm compression* cock.



Figs. 8,127 to 8,129.—Lukenheimer self-grinding gauge cocks. Fig. 8,127, short shank with lever; fig. 8,128, long shank with lever; fig. 8,129, long shank without lever. ***In operation,*** when the lever is moved to open position, the projection X (fig. 8,127) presses against the loose piece A, which forces back the stem E, and unseats the disc, allowing steam or water to pass out of the nozzle. The guide next the disc is provided with spiral grooves, so that the water or steam in passing through these spirals will impart a rotary motion to the stem E. When the pressure on the loose piece A, is released, the boiler pressure forces the valve to its seat, while the stem is rotating, thus grinding in the seat bearing a little every time the cock is opened. The piece A, being independent precludes the possibility of wedging between stem and body.

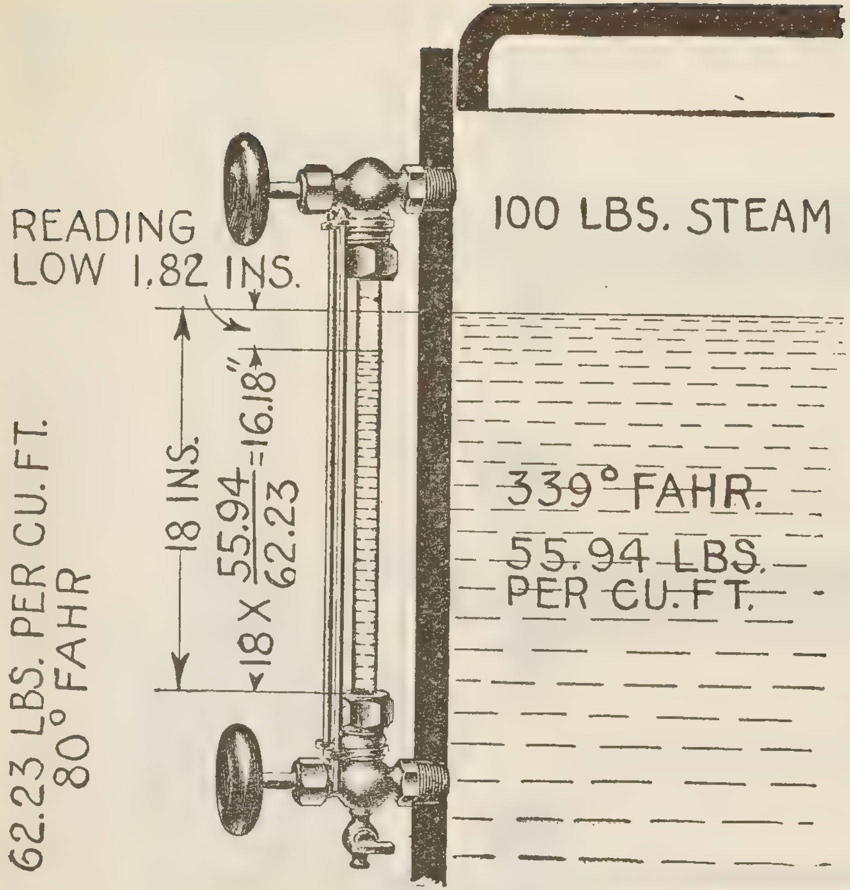
water level within the boiler, and the principal means for ascertaining this is the water gauge cocks.

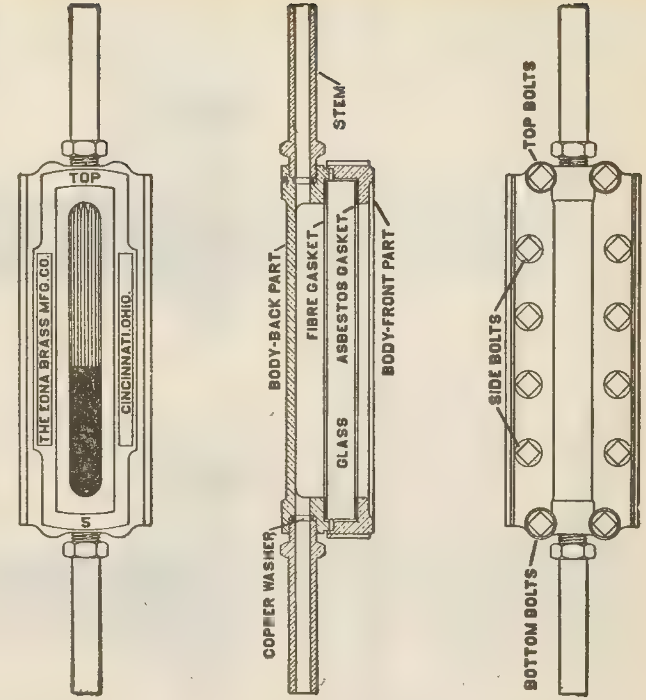
Usually three cocks are provided (except on very small boilers which sometimes have only two), the upper and lower cock being placed at the safe high and low water levels respectively, and the third cock midway between.



FIGS. 8,130 and 8,131.—Why the author objects to crank handles on cocks or any other screw fittings. The illustrations require no explanation; however, it might be mentioned that cocks like nuts are usually screwed without judgment, that is closed with entirely too much force, hence a considerable turning force is sometimes required to open them. When this force is applied to a crank as in fig. 8,130, since it is unbalanced, the lateral thrust must be resisted by the threads at diagonally opposite points. Moreover, when the threads become worn from this abuse, as soon as the crank begins to turn the alignment is destroyed and the valve tends to dig into the seat at **L**, and to leave it at **F**, here shown exaggerated for clearness. The unequal grinding effect tends to cause a leak at **F**.

To ascertain the water level, each cock is opened *slightly* and the presence of water, or steam in the escaping jet is tested by its appearance, sound, and feel to the hand. With a little experience there can be no mistake made in determining the water level by means of the gauge cocks.





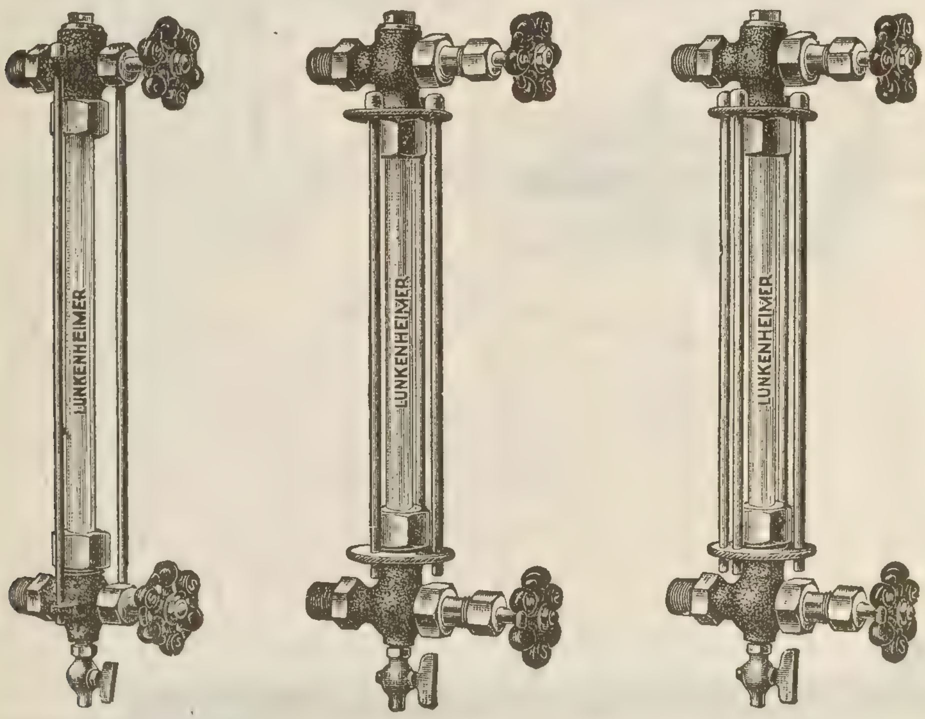
FIGS. 8,133 to 8,135.—Edna ***reflex*** water gauge. The effect of the corrugated surface of the glass in contact with the water is such that the water can be plainly seen even in dim light as the water shows as a black liquid the space not occupied by water appears as silver white, a well-marked water line. The gauges are suitable for pressure up to 300 pounds.

FIG. 8,132.—Why a water gauge does not register the correct water level. Since the water in the tube is not in circulation it is quickly cooled, especially on exposed boilers, thus there is a considerable difference in temperature between the water in the boiler and that in the tube. Suppose the boiler be under 100 pounds steam pressure, the corresponding temperature of the water is 338.7° and the weight of a cubic foot of water at this temperature is 55.94 pounds; also if the water in the tube be cooled down to, say 80°, the corresponding weight per cubic foot is 62.23 pounds. Now, if the height of the water in the boiler be 18 inches above the bottom of the gauge, as shown, the height of the water in the gauge will be $18 \times 55.94 \div 62.23 = 16.18$ inches, or $18 - 16.18 = 1.82$ inches lower than that in the boiler. Although the gauge always indicates less than the true level; *this should **not** be considered in the emergency of low water with disabled feed pumps.*

The reason the valve is only opened slightly is because a full opening tends to raise the water level, thus indicating a false level, as in figs. 8,121 and 8,122.

There are numerous kinds of water gauge cocks, a type in common use being shown in figs. 8,121 and 8,122.

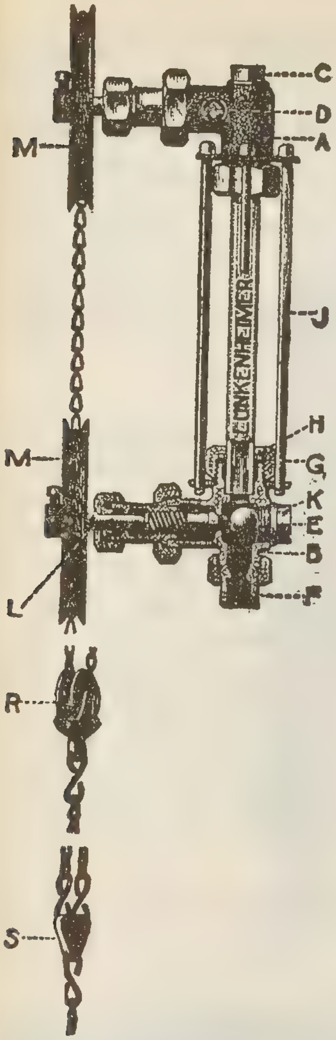
Water Gauge.—This should be regarded as a secondary means of ascertaining the water level, although most engineers



FIGS. 8,136 to 8,138.—Lunkenheimer, two, three, and four rod plain cylindrical water gauges. The plug in the top fitting prevents replacing the glass tube.

acquire the bad habit of relying on it almost entirely. The water gauge consists of a strong glass tube, long enough to cover the safe range of water level, and having the ends connected to the boiler interior by fittings.

It is connected to the boiler at such elevation that the lower and upper ends of the tube will be the lowest and highest permissible water levels. The two principle forms of water gauge are shown in figs. 8,132 to 8,135.



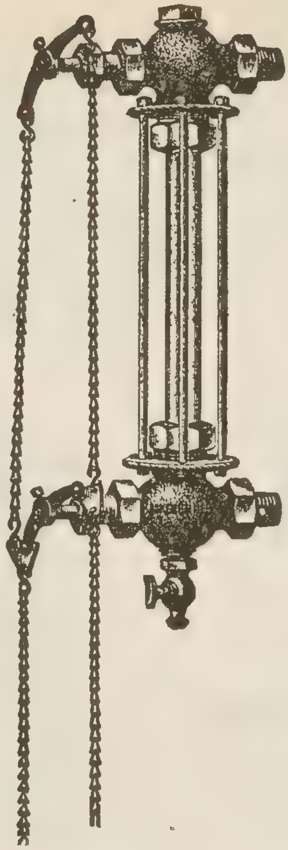
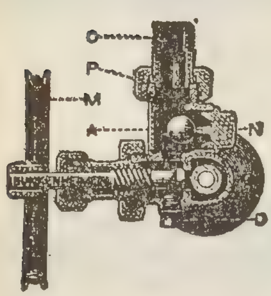
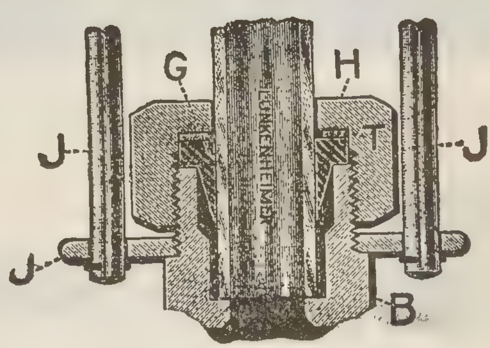
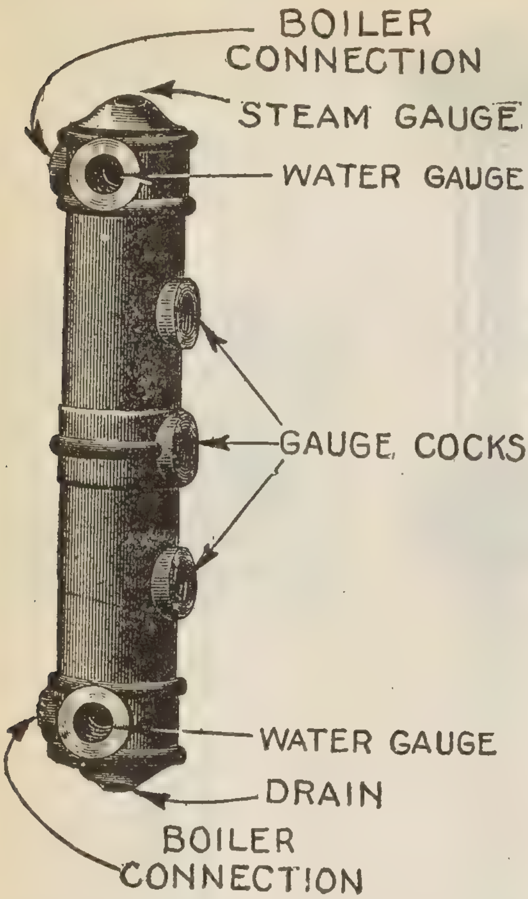


FIG. 8,142. — Lunkenheimer lever quick closing cylindrical water gauge. The chain control adapts the gauge for tall vertical boiler where it is far removed from the floor, and in case the glass break it can be shut off from the flow by pulling down on the chain, thus avoiding the difficult operation of closing a gauge when standing on a ladder.





FIGS. 8,139 to 8,141.—Lunkenheimer "Monitor" automatic pulley quick closing cylindrical water gauge and details. ***The parts are:*** A, upper head; B, lower head; C, upper clean out plug; D, side plug; E, lower head plug; F, drain connection; G, packing; H, supply box cap; J, guard; K, shut off ball; L, lower valve stem; M, control pulleys; O, glass; P, stuffing box; R and S, chain gear; T, gasket.



Water Column.—Frequently the gauge cocks and water gauge are connected to a central column, the assembly being known as a water column. On a well designed column there are nine openings as shown in fig. 8,143.

An improved form of water column is the so called safety or alarm column, as shown in figs. 8,147 and 8,148 having an automatic whistle, which blows in case of low water and awakens the firemen and other attendants supposed to be on duty.

Sometimes water columns are made up of wrought pipe and fittings, as is used on some marine water tube boilers. This construction forms a light, yet substantial column.

FIG. 8,143.—Water column without fixtures showing the various openings and what they are for.

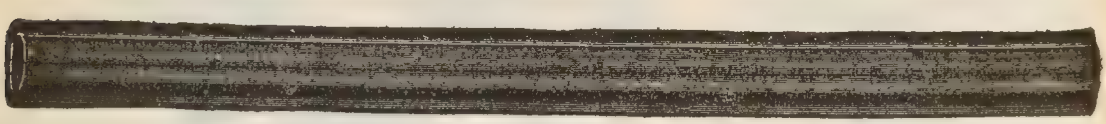
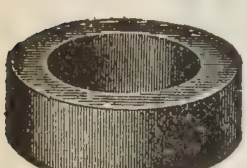


FIG. 8,144.—Scotch water gauge glass. Usually carried in stock in sizes from ½ to ¾ ins. diameter and from 10 to 24 ins. in length.



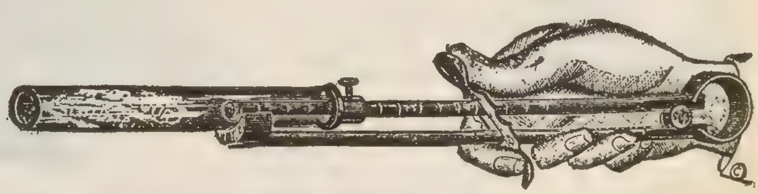
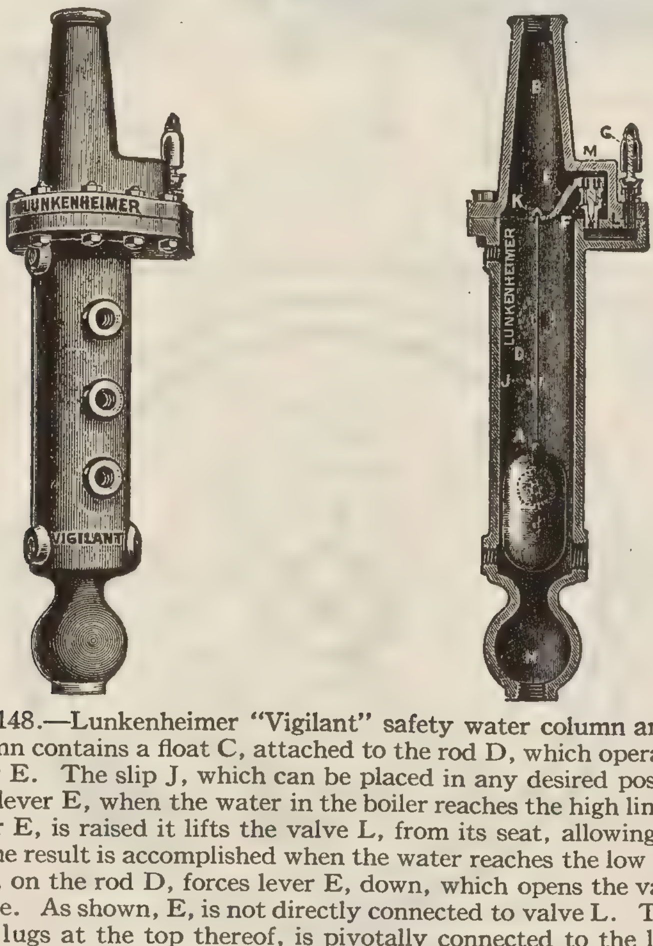


FIG. 8,145.—Gauge glass washer or *grommet*, which forms the stuffing box packing to make tight joints at each end of the glass.

FIG. 8,146.—Patent gauge glass cutter.

Steam Gauge.—This is a very important fixture and one which should be tested from time to time to ascertain if it correctly indicate the steam pressure.

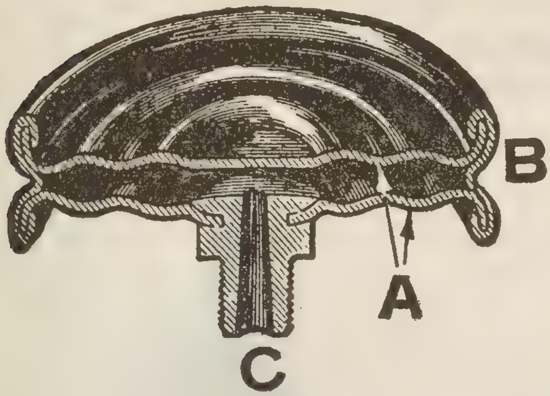
A steam gauge indicates the difference of pressure inside and

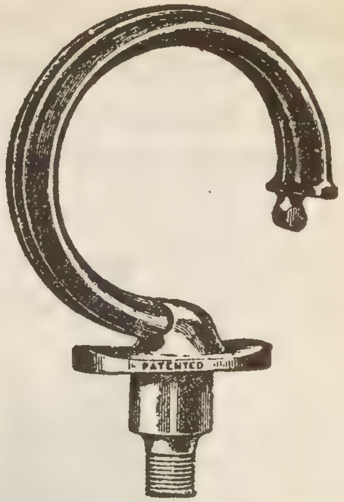


FIGS. 8,147 and 8,148.—Lunkenheimer "Vigilant" safety water column and detail of whistle valve. The column contains a float C, attached to the rod D, which operates through a hole in the valve lever E. The slip J, which can be placed in any desired position in the rod D, strikes the valve lever E, when the water in the boiler reaches the high limit. ***In operation*** as the valve lever E, is raised it lifts the valve L, from its seat, allowing steam to blow the whistle. The same result is accomplished when the water reaches the low limit. As the float falls, the knob K, on the rod D, forces lever E, down, which opens the valve allowing steam to blow the whistle. As shown, E, is not directly connected to valve L. The valve casing M, by means of two lugs at the top thereof, is pivotally connected to the lever. Within this casing is fitted valve L, the arrangement insuring proper contact of valve with its seat. H, is a sediment chamber with the lower end tapped to receive pipe to blow out sediment.

outside the boiler, that is, it indicates the *gauge* pressure as distinguished from the *absolute* pressure.

A steam gauge works on one of two principles: 1, the expansion of a corrugated diaphragm when pressure is applied, and





Figs. 8,149 and 8,150.—Diaphragm and bent tube as used in the two classes of steam gauge.

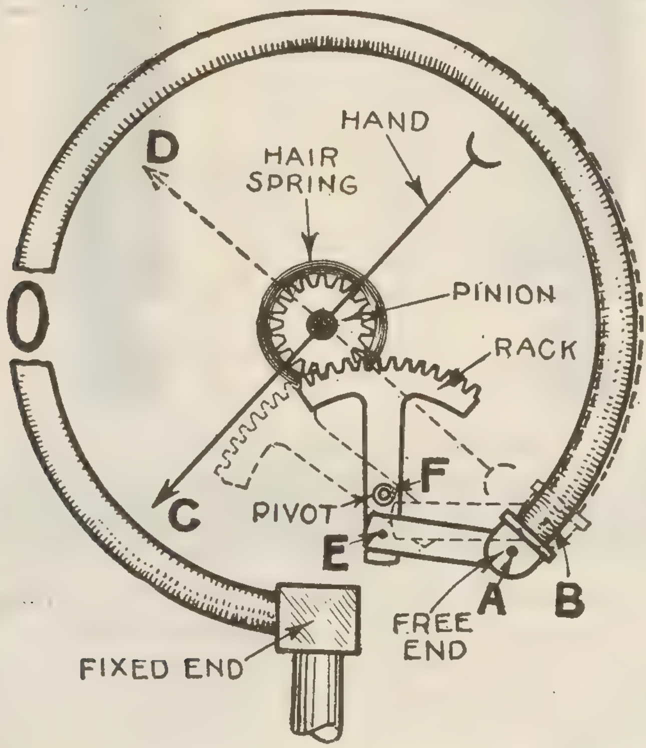
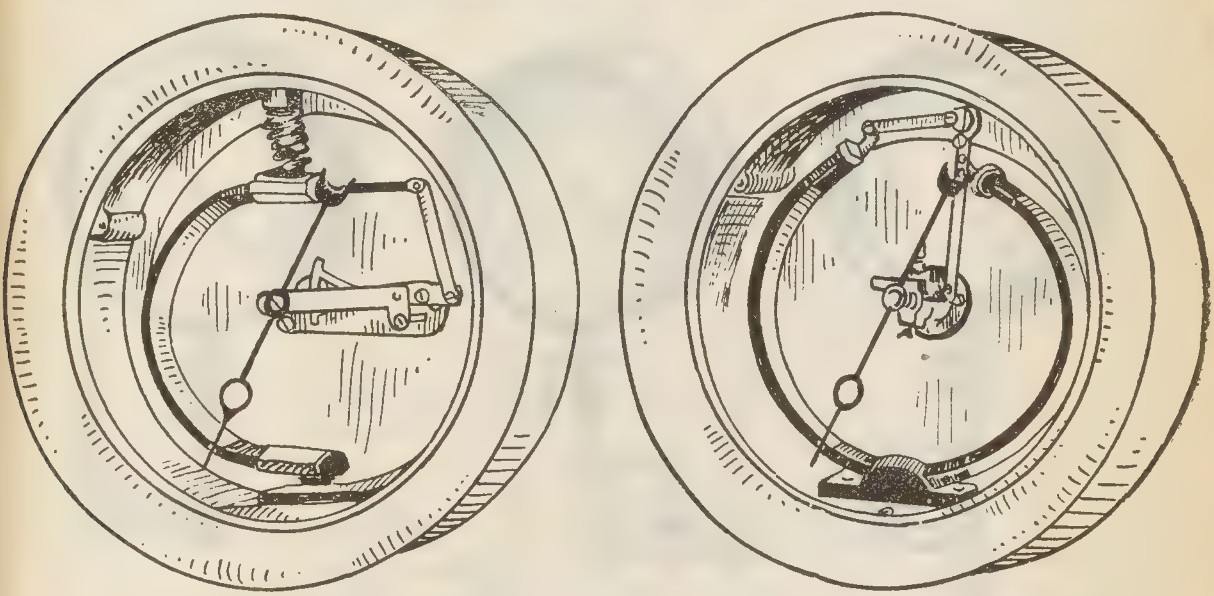


Fig. 8,151.—Multiplying mechanism of a bent tube steam gauge, showing zero position in full lines, and one position under pressure in dotted lines. The free end, **A**, of the tube is connected by a link to the rack arm at **E**, the latter being pivoted at **F**, as shown. Evidently when the free end of the tube moves a short distance, as from **A**, to **B**, the motion of the pointer or indicating hand will move a much greater distance as from **C**, to **D**. ***In construction,*** by making **EF**, of suitable length, any degree of sensitiveness may be obtained, thus adapting the gauge for a low or high range of pressure. The hair spring which is connected with the pointer shaft, offers a slight resistance which takes up the lost motion in the mechanism and renders it "taut" at all times.

2, the tendency of a curved tube to assume a straight position when under pressure.

Figs. 8,149 and 8,150 show the mechanical details. Fig. 8,149 represents a section of a pair of metal plates or diaphragms, A. These are made with circular corrugations, as shown in section and also by the shading. The steam enters by the pipe C, and fills the chamber between the metal plates or diaphragms. The corrugations of the latter give them sufficient elasticity, so that when the pressure is exerted between them they will be



FIGS. 8,152 and 8,153.—***Single*** and ***double*** tube steam gauges; interior views showing mechanism. The double tube movement has an auxiliary spring at the free end of the tube.

pressed apart by the steam. If they were flat, it is evident that they would not yield, or only to a very slight degree, to the pressure of the steam.

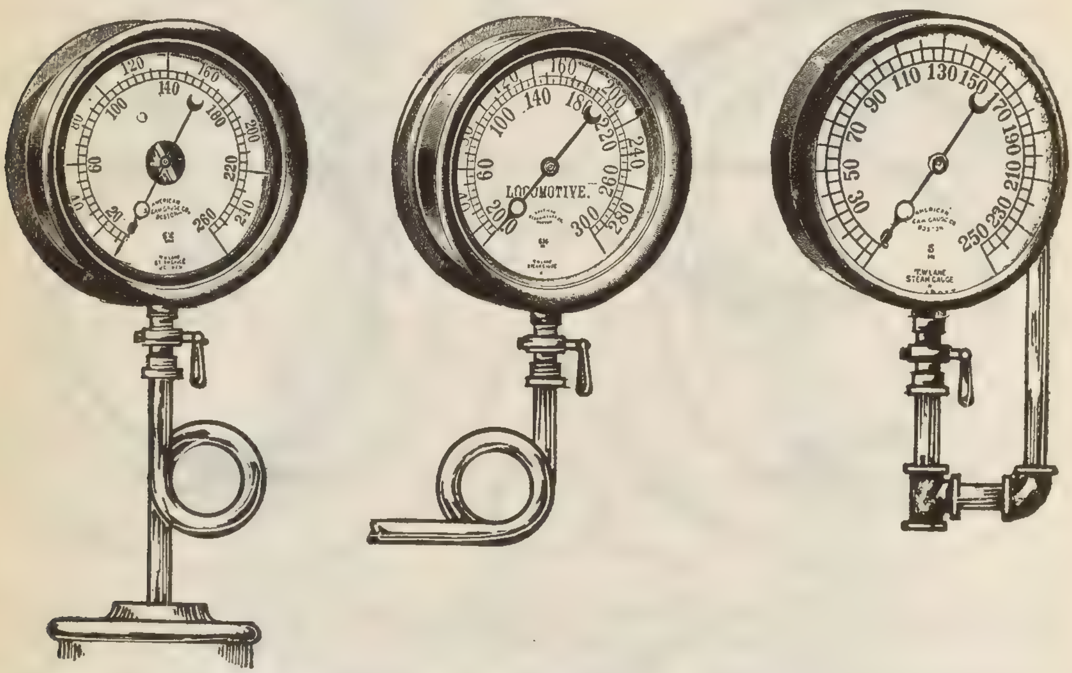
Fig. 8,150 shows the bent tube construction.

The tube is of flattened or elliptical section to render it more sensitive to the pressure. This is due to the fact that the pressure tends to force the flattened sides apart which in turn increases the tendency of the tube to straighten itself.

The bent tube principle is now almost universally used in steam gauge construction. Since the movement of the free end of the tube is very small, its motion is *multiplied* by means of a segmental rack which actuates a small pinion on a pointer shaft as shown in fig. 8,151.

When a gauge is in good working order, the index or pointer moves easily with every change of pressure in the boiler, and if the steam be shut off from the gauge, the index should always go back to 0.

In connecting a steam gauge to a boiler, a turn or two of pipe is placed between the boiler and the gauge as shown in figs. 8,154 to 8,156. The bend of the pipe gradually filling with



FIGS. 8,154 to 8,156.—Various forms of connection for steam gauge. The pocket formed by the connection becomes filled with water of condensation which protects the spring from the heat of the steam.

condensed steam, prevents the live steam touching the elastic discs or tubes.

Any gauge will be ruined unless thus protected, especially if superheated steam be used. A gauge should be located in a cool place and secured to some substantial object where it will be free from vibration or jar. Before connecting a gauge *the goose neck should be filled with water to protect the bent tube from the hot steam.*

Injectors.—An injector is an instrument for forcing water into a boiler against the boiler pressure by means of a steam jet.

Principle of the Injector.—An injector forces water into the boiler because *the kinetic energy of a jet of steam is much greater than that of a jet of water escaping under the same conditions.*

The simplest form of injector is shown in fig. 8,157, in which the details

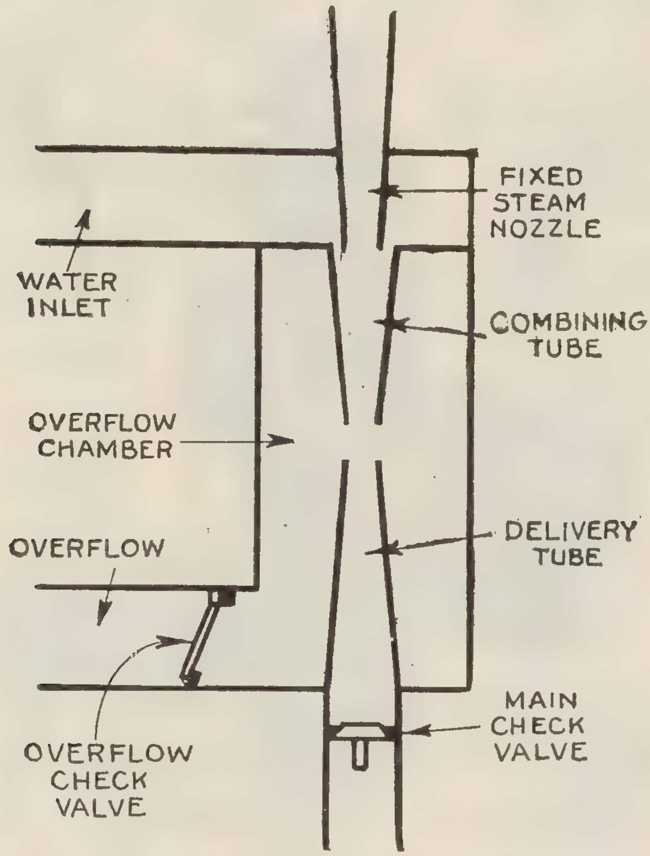
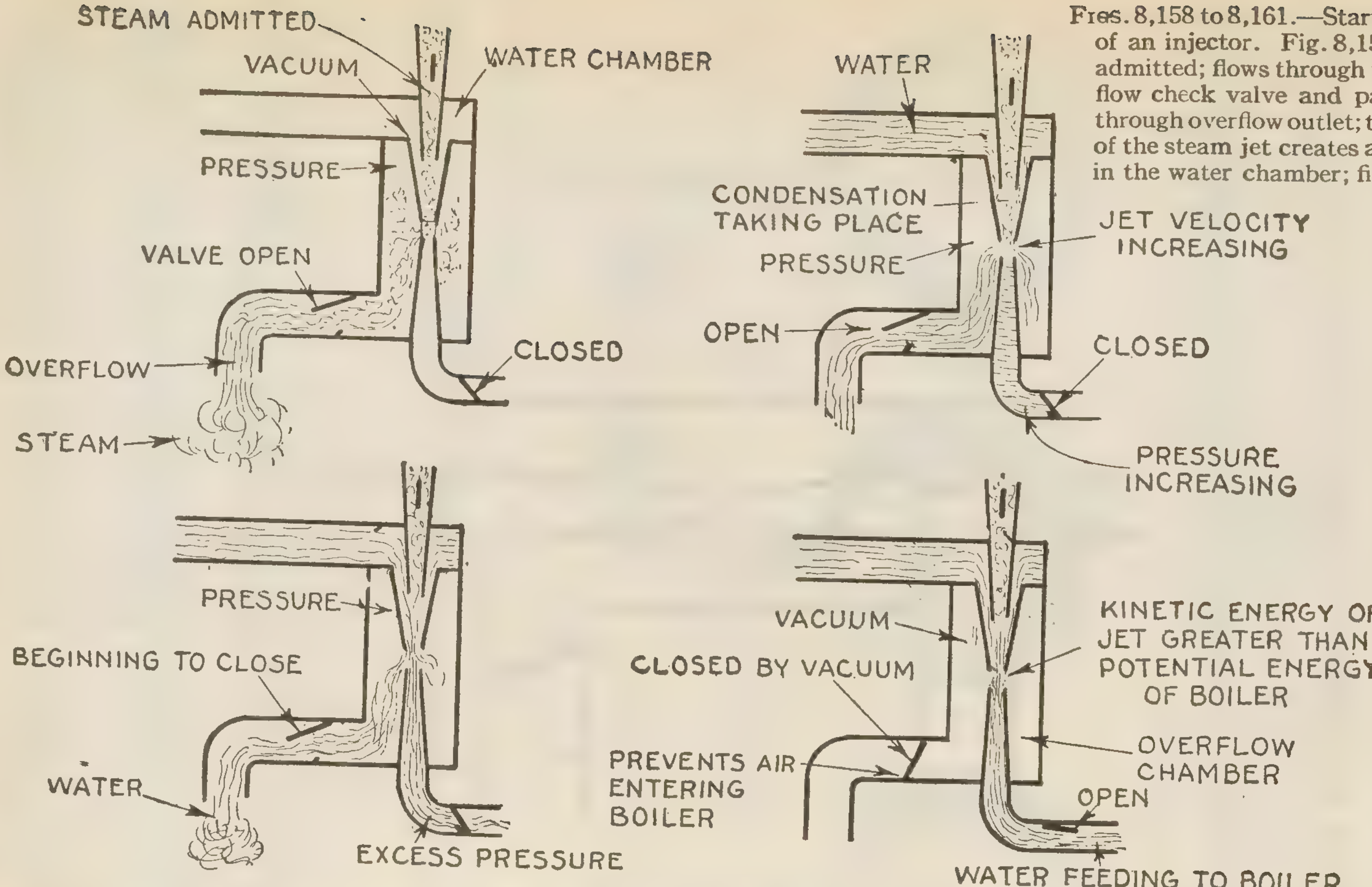


FIG. 8,157.—Rudimentary fixed nozzle, ***single tube,*** injector. The assembly of a steam nozzle, combining and delivery tubes is called a *single tube* injector, as distinguished from a double injector which has two sets of nozzles and tubes, one for lifting, and one for forcing.

of construction are omitted. It consists of: 1, a steam nozzle; 2, combining tube; 3, delivery tube with check valve; 4, inlet for water, and 5, overflow.

In operation, steam from the boiler, entering the steam nozzle, passes through it, through the space between steam nozzle and combining tube,



Figs. 8,158 to 8,161.—Starting cycle of an injector. Fig. 8,158, steam admitted; flows through the overflow check valve and passes out through overflow outlet; the action of the steam jet creates a vacuum in the water chamber; fig. 8,159, vacuum created in water chamber draws in the water, which meeting the steam in combining tube, condenses and the jet of steam issuing from overflow (fig. 8,158) becomes a jet of water rapidly increasing in velocity, which builds up pressure against the boiler check; fig. 8,160, the continued increase in velocity of jet causes pressure against boiler check to exceed boiler pressure and the latter begins to open, part of the jet water entering boiler and part flowing out through overflow; fig. 8,161, velocity of jet has become so great that all resistance is overcome, the check valve being forced wide open, all the water entering boiler. The action of the jet now creates a vacuum in the overflow chamber, which causes overflow valve to close, thus shutting out the air which would otherwise be forced into the boiler.

and then out through the overflow. This produces a vacuum which draws in the water through the water inlet.

The incoming *cold* water condenses the steam in traversing the combining tube and the water jet thus formed is, at first, driven out through the overflow, but as the velocity of the water jet increases, sufficient momentum is obtained to overcome the boiler pressure, with the result that the water enters the delivery tube, and passes by the *main* check valve into the boiler.

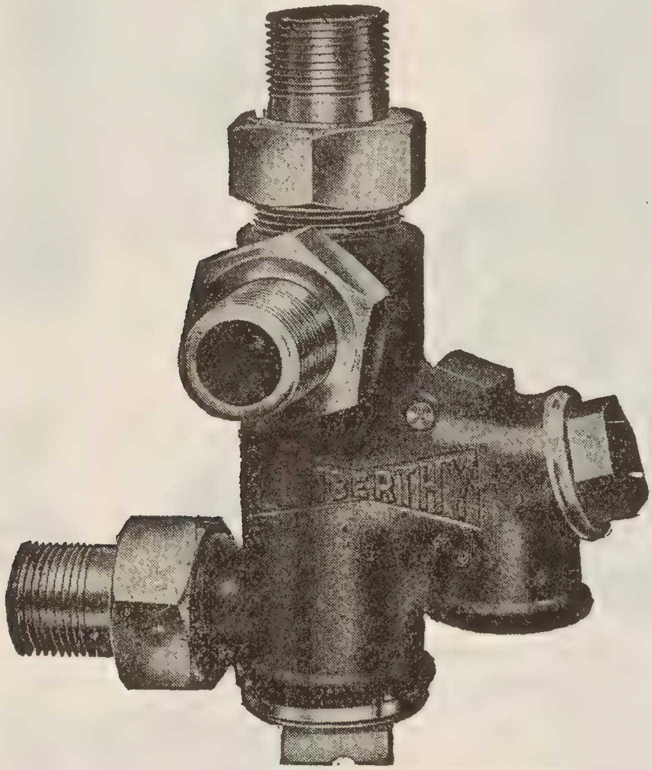
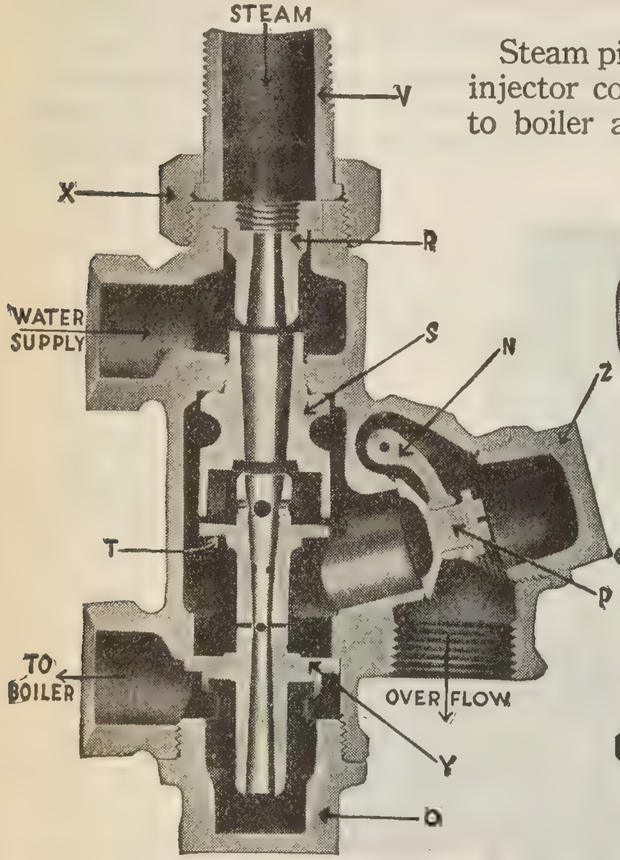


FIG. 8,162.—Penberthy non-lifting automatic injector, for low pressures as employed in steam heating plants.

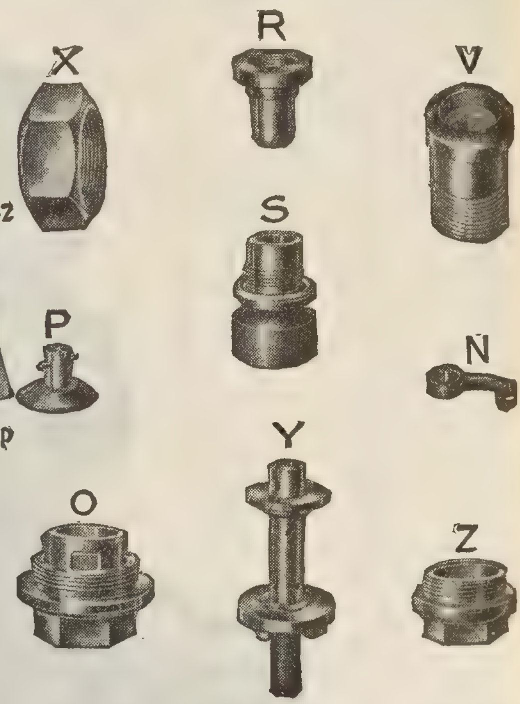
When the jet of water begins to flow into the boiler, it produces a vacuum in the overflow chamber as it passes the space between the combining and delivery tubes which causes the overflow check valve to close, this prevents air entering the delivery tube.

There are numerous kinds of injectors, one form especially suited for low pressure steam heating boilers is shown in fig. 8,162.

In installing an injector there are three pipe connections to be made, and it is important that these connections be properly made as shown in fig. 8,174.



Steam pipe D should always be same size as injector connections, and must be connected to boiler at the highest possible point, and



FIGS. 8,163 to 8,172.—Penberthy single tube fixed nozzle lifting automatic injector. ***The parts are:*** R, steam jet; S, suction jet; T, ring valve; Y, delivery jet; O, plug; V, tail pipe, X, coupling nut; N, overflow hinges; P, overflow valve; Z, overflow cap. ***In operation,*** momentary period elapses between the opening of injector steam valve and the establishment of the jet of water to boiler. During this interval the steam and water must not be allowed to back up in suction line, hence a series of exhaust openings are provided at intervals along the jet passages. At first the steam and water exhaust from all these openings or "spills," then the establishment of the jet of water begins at the top and proceeds downward. It is therefore possible for the exhaust from lower spills to be drawn in again into the upper spills. Under such conditions the upper zone of injector may be established and have ceased to "spill," thus inducing an inward suction at upper spills. Now this upper zone has established because the steam and water quantities were rightly proportioned for that instant and that zone. But if the lower zone (which is not yet established) be allowed to throw its surplus back up and into the upper zone, the upper zone will again be disturbed and unbalanced. Therefore the ring valve is used to prevent such an occurrence. Just as soon as suction is developed at upper spills, the ring T, is drawn upward to its seat on jet S, forming an auxiliary chamber around upper zone for its protection. This ring valve T, is to the upper zone just what the outer overflow valve P, is to the injector as a whole. Without the ring T, the injector could not be operated on the lower steam pressures. When water is taken from pressure source a special large steam jet is employed. Hot water is not favorable for low starting. Standard temperature for local tests is 74° Fahr.

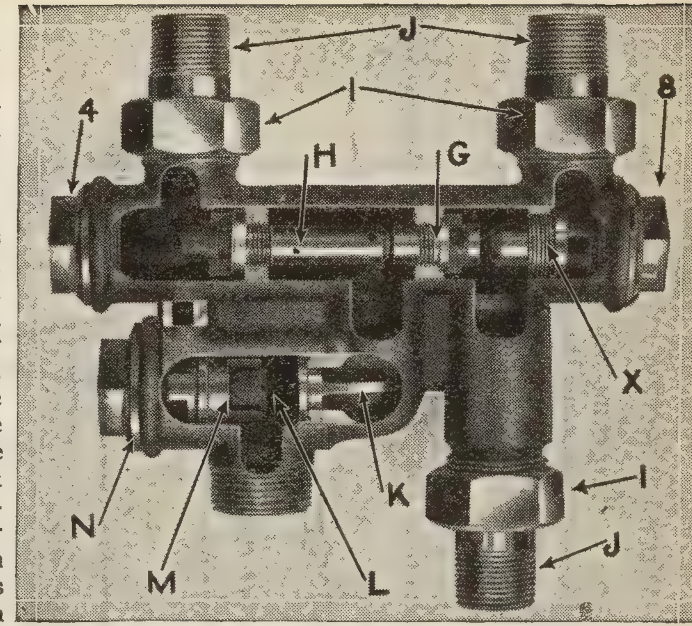


FIG. 8,173.—Penberthy ***auto-positive*** injector. ***In operation,*** steam being admitted, the water is raised and forced through overflows from vacuum chamber through valve K, and from pressure chamber through valve L, the object of valve L, is to allow the injector to be started against atmospheric pressure, no matter what the steam pressure within its range, and when started, the boiler pressure holds valve L, to its seat and that in turn holds valve K, near its seat, thus accomplishing the closing of the overflow automatically which in positive double tube injectors requires a positive hand closed valve. The advantages claimed are: 1, very hot water is handled as high as 135° Fahr., and a range of 25 to 200 lbs., working steam pressure is secured; 2, automatic action; 3, if injector "break," the steam and water escape at overflow instead of going down the suction pipe, as with a positively closed overflow. ***The parts are,*** 8, steam plug; X, steam jet; G, suction jet; H, delivery jet; 4, delivery plug; N, overflow plug; L, pressure valve; M, pressure valve collar; K, vacuum valve; I, coupling nut; J, tail pipe.

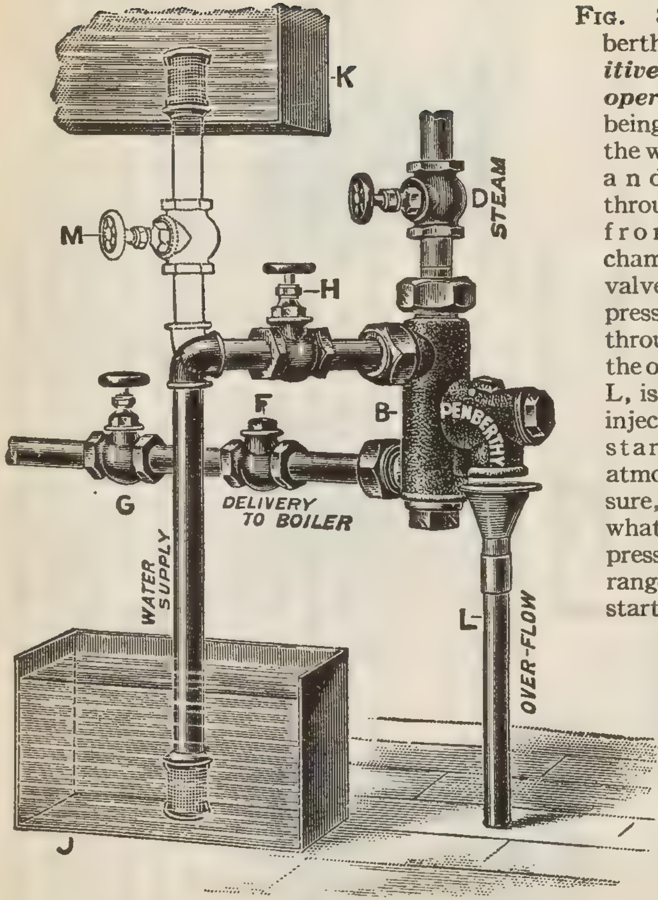


FIG. 8,174.—Penberthy single tube fixed nozzle lifting ***automatic*** injector with connections. B, injector; D, globe valve in steam pipe; F, check valve in delivery pipe; G, globe valve in delivery pipe; H, globe valve in suction pipe; J, water supply taken from below injector; K, water supply taken from overhead tank; L, waste pipe from overflow; M, second globe valve in water supply pipe where an overhead tank is used or supply is taken from water works pressure.

independently of any other pipe in order to secure best results. This pipe must be blown out with steam before connecting injector.

Suction pipe H, must always be as large as injector connections, and where lift is over 10 ft., should be one or two sizes larger, reducing to injector size as near injector as possible and having a globe valve same size as larger pipe. Be sure and put a globe valve (not a straightway) in the water supply pipe.

On a long lift, a foot valve should be placed on lower end of suction pipe.

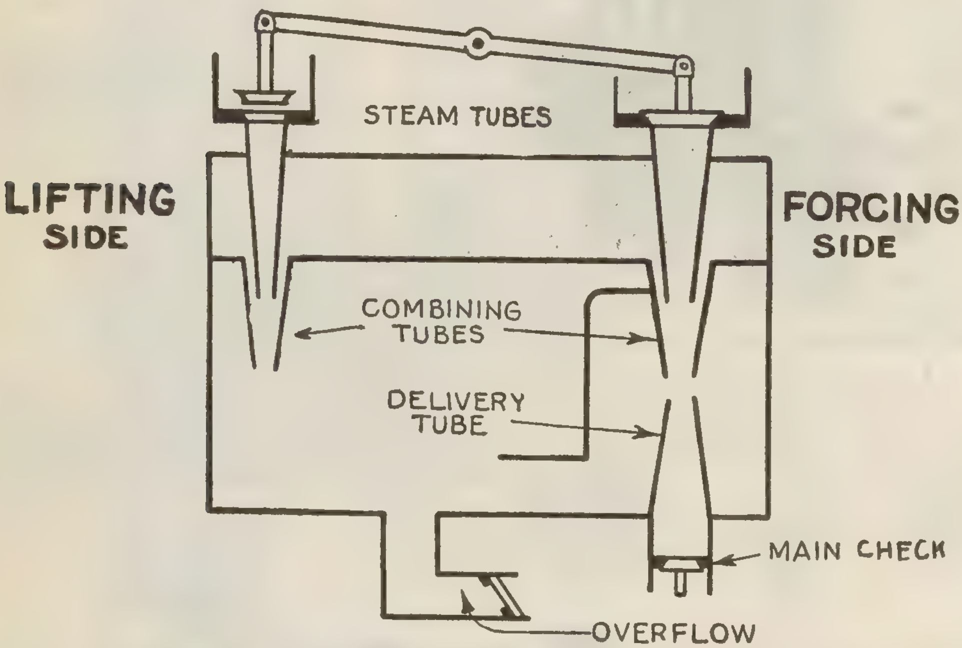
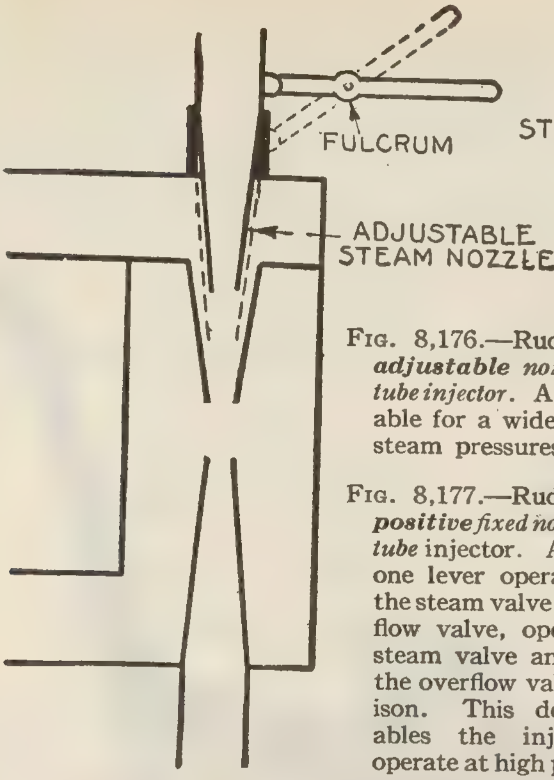


FIG. 8,175.—Rudimentary fixed nozzle, ***double tube*** injector. In this type the lifting tube lifts the water to the injector, and the forcing tube forces the water into the boiler. This type is adapted to high lifts.

Without a foot valve, every time the injector is started the air must all be exhausted from the suction pipe before the water can reach the injector and considerable steam is wasted. With a foot valve, the water is held in the pipe when injector is stopped, and is there when starting again, so that the saving in steam will soon pay for the cost of this valve.

When the water pressure is heavy, such as is usual where there is a city water works, to facilitate starting on low steam, many persons use two globe valves H and M in the water supply pipe, one as near the injector as possible, and the other several feet away, forming a well between the two. The far away valve M. can then be used to reduce the pressure and the one near the injector for regulating the water supply.



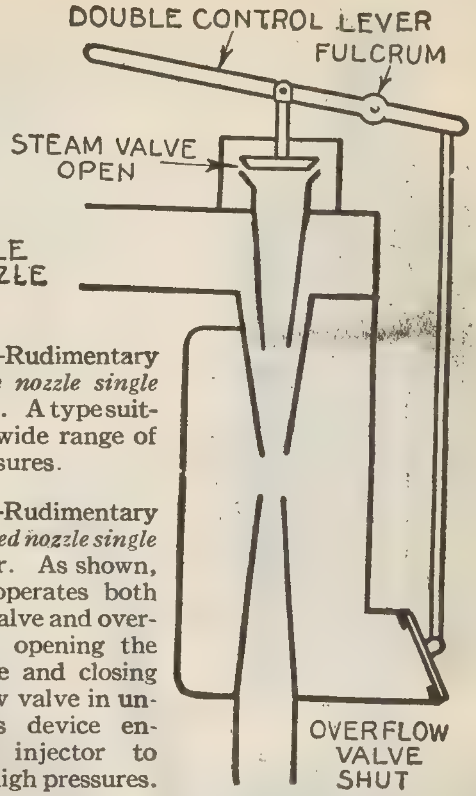
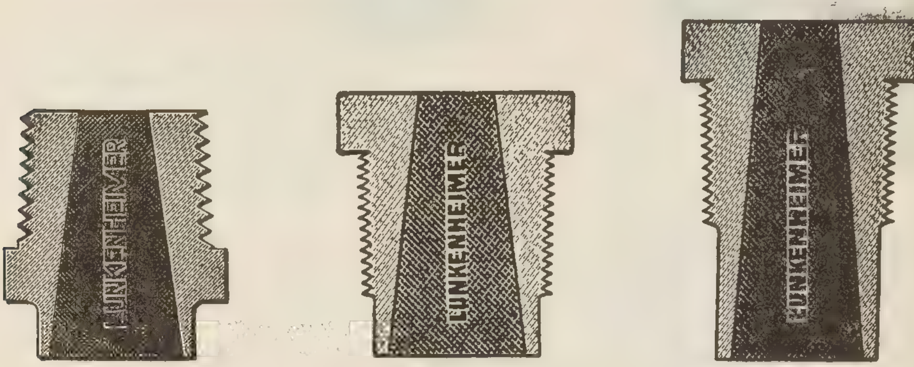


FIG. 8,176.—Rudimentary ***adjustable*** *nozzle single tube injector*. A type suitable for a wide range of steam pressures.

FIG. 8,177.—Rudimentary ***positive*** *fixed nozzle single tube* injector. As shown, one lever operates both the steam valve and overflow valve, opening the steam valve and closing the overflow valve in unison. This device enables the injector to operate at high pressures.

An ordinary injector can be made positive by placing a stop cock in a short piece of pipe screwing into the overflow, and closing the cock after injector is started. It should be noted that such stop cock arrangement renders injector non-automatic while the stop cock is closed.



FIGS. 8,178 to 8,180.—Lunkenheimer fusible plugs. Fig. 8,178, inside type; fig. 8,179, outside type; fig. 8,180, extra .ong pattern outside type. The plugs are made of bronze and are filled with pure Banca tin in accordance with the requirements of the Board of Supervising Inspectors.

NOTE.—***In determining the size of*** injector, it is a mistake to select one which will be required to work at its limit of capacity, steam pressure, lift, or temperature of feed water, for if used at its limit any appreciable wear is almost sure to cause trouble.

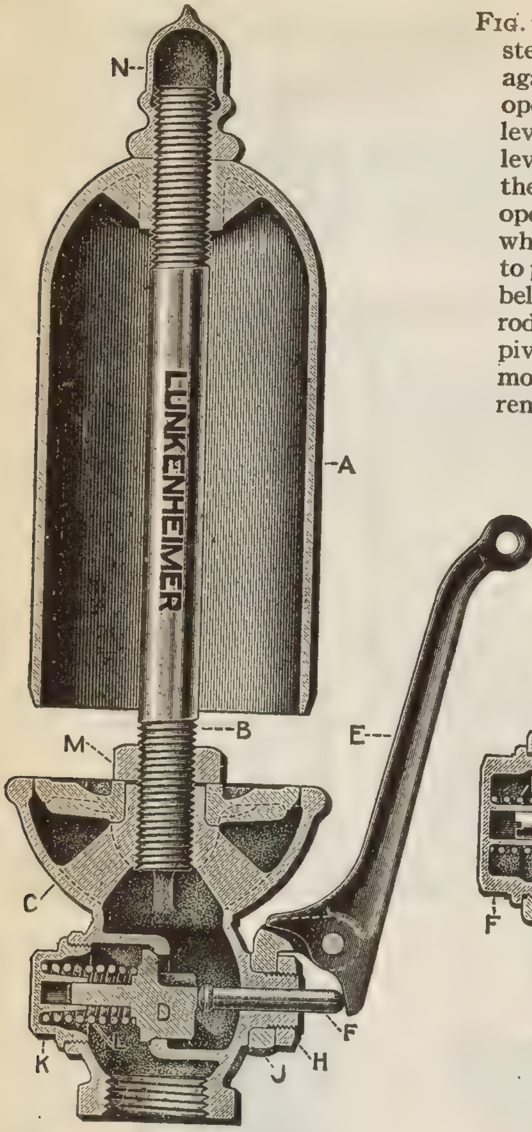


FIG. 8,181.—***Single tone*** whistle. The supply of steam is regulated by the valve D, which opens against a weak spring L, and the steam pressure, the opening force being applied to the stem F, through lever E, by means of a chain or wire attached to the lever at its upper end. The sound is produced by the rush of steam in a thin cylindrical sheet through opening M, directly against the edge of the whistle bell A, in which the vibrations necessary to produce the sound are produced. The bell is held in place by the threaded rod B, and jamb nut N. The lever pivot J, is secured by nut H. By removing cap K, the valve may be removed for examination or repair.

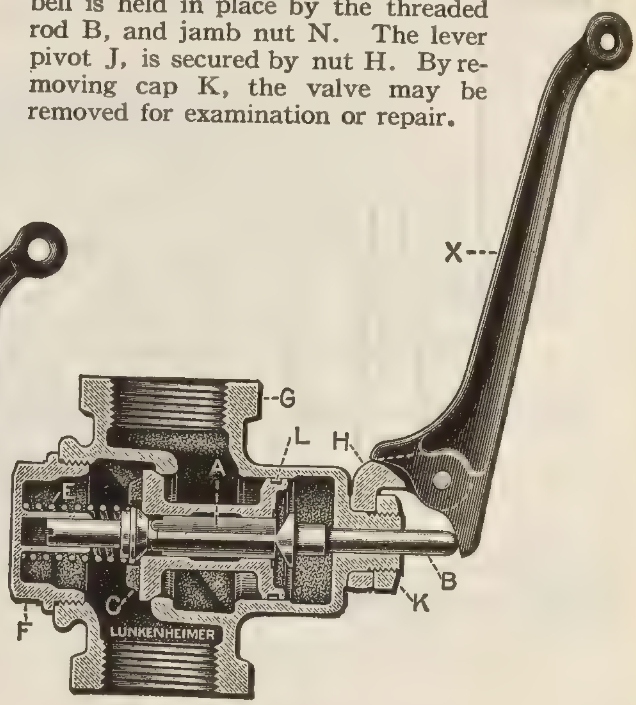


FIG. 8,182.—Lunkenheimer balanced whistle valve. ***In operation,*** steam pressure on the disc C, normally holds it to its seat. A slight pull on lever X, suffices to open the small auxiliary valve A. This admits steam through the opening in the center of the stem of valve C, to expansion chamber where it acts upon the piston, the area of which, being equal to that of valve C, practically balances it, and with only a slight additional pressure, the valve opens wide. When lever is released, the spring E, closes auxiliary valve A, and the main valve C, closes easily without jar, as the steam entrapped in the balancing expansion chamber tends to cushion and retard its movement.

The delivery pipe should be same size as injector connections, or larger if desired. There should be a check valve F, and also a stop valve G, in this pipe, the latter for use in case the former gets out of order.

Fusible Plug.—This is a safety device which acts in case of dangerously low water. It consists of a core of an alloy of tin, lead and bismuth, and a covering of brass or cast iron as shown in Figs. 8178 to 8180.

Separators.—The object of a separator is to remove as much

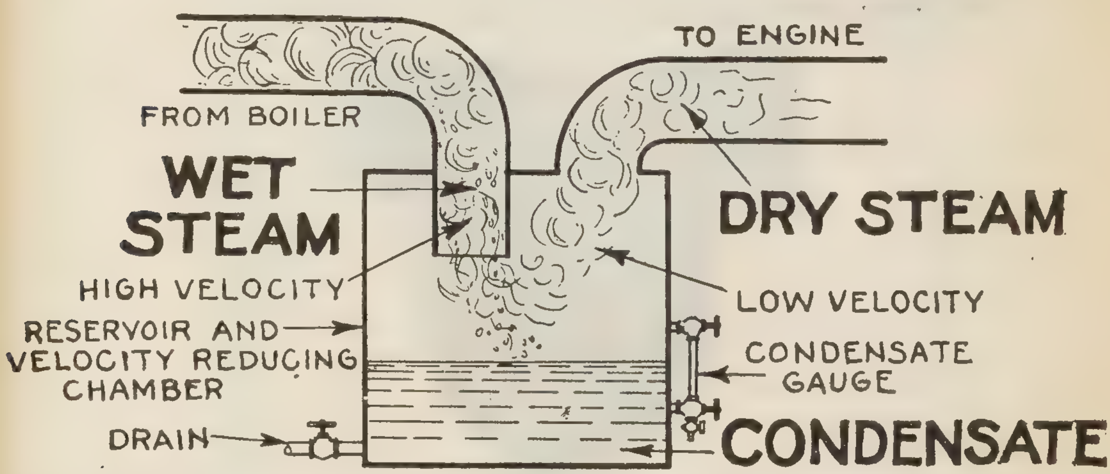


FIG. 8,183.—Elementary steam separator, illustrating principles of operation. Steam from the boiler is led into a chamber of larger section than the pipe, and out again after: 1, having its *direction suddenly changed* (usually through 180°), and 2, having its ***velocity reduced*** while passing through the chamber. *Change in direction of the steam flowing at 6,000 to 8,000 feet per minute creates considerable* ***centrifugal*** *force which acting on the heavy globules,* ***hurls*** *them out of the path of the steam.* The velocity of the steam in changing its direction is reduced because of the large size of the chamber which diminishes the disturbance due to the steam passing through the chamber, thus increasing the efficiency of the device.

moisture as possible from the steam *after* it leaves the boiler. It is placed close to the engine so as to avoid any further condensation between separator and engine.

All separators employ centrifugal force (sometimes aided by gravity), to remove moisture, by arranging the device so as *to* ***suddenly*** *change the direction of flow of the stream.*

The water globules being much heavier than the steam, continue in the same direction because of their momentum, and are accordingly hurled out

of the steam and by suitable provision are led into a receiver and drawn off from time to time, as shown in fig. 8,183.

Steam Loop.—This is an arrangement of piping wherein *condensate* is returned to the boiler. It consists of four essential parts:

1. Riser;
2. Goose neck;
3. Condenser;
4. Drop leg.

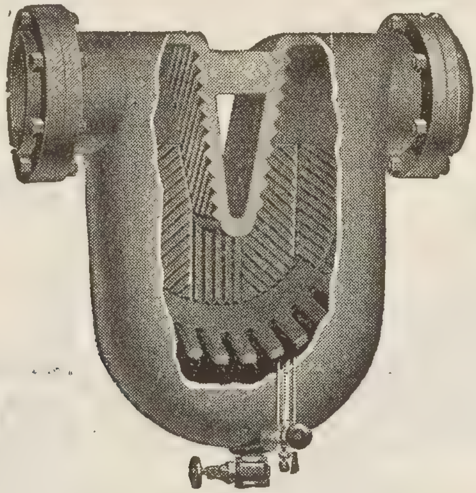


FIG. 8,184.—Austin separator. The baffle plate which serves to change the direction of the steam flow is not set at right angles to the entering steam current, but is set at an angle so that when the steam is impinged against it, the particles of water rebound at an opposite angle. This sets up a rotating motion in the steam, bringing the latter in contact with the inside walls of the separator. These walls are heavily corrugated, as is also the surface of the baffle plate, and all corrugations are designed so as to carry the drainage out of and away from the course of the steam. Any moisture not caught by the upper baffle plate and by the inner walls, is subject to further separation process by means of additional baffle plates located in the well or receiver portion of the separator, one of these plates being shown in the illustration. The separator is adapted for steam flow in either direction.

Fig. 8,185 shows these essential parts, each of which has its special and well defined duty to perform, and their proportions and immediate relations determine the capacity and strength of the system.

The *riser* does not contain a solid body of water, but a mixture of water and steam.

The steam part of the mixture is readily condensed by means of the *condenser* at the top, usually and erroneously called the *horizontal pipe.* This condensation reduces the pressure in the system which causes an upward flow of the mixture in the riser, that is, the riser is constantly supplying steam, conveying large quantities of water in the form of a fine spray to take the place of the steam condensed in the condenser.

As soon as the water mixed with the steam passes the *goose neck,* it cannot return to the riser; hence the contents of the pipes constantly work

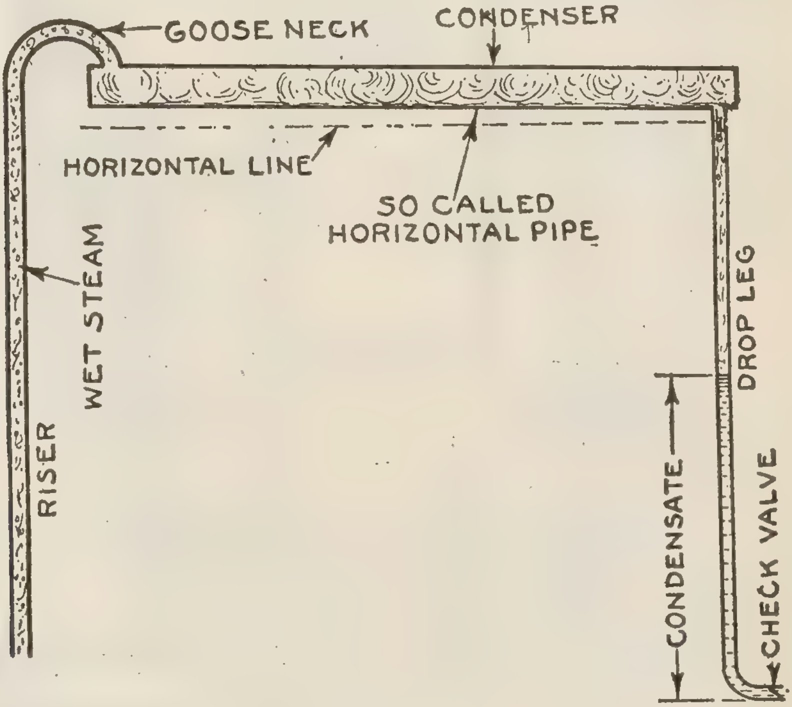


FIG. 8,185.—Essential parts of a steam loop: 1, riser; 2, goose neck; or non return device; 3, condenser, commonly and erroneously called the horizontal pipe; 3, drop leg, or balancing pipe. A check valve is placed at the end of the drop leg to prevent surging or fluctuating of the water level, thus rendering the operation stable. There are two conditions necessary for proper operation of a loop: 1, sufficient length of drop leg to balance the pressure reduction due to ***weight and friction*** of the mixture in the riser; 2, sufficient cooling surface of condenser to condense at a rate which will give the proper flow in the riser.

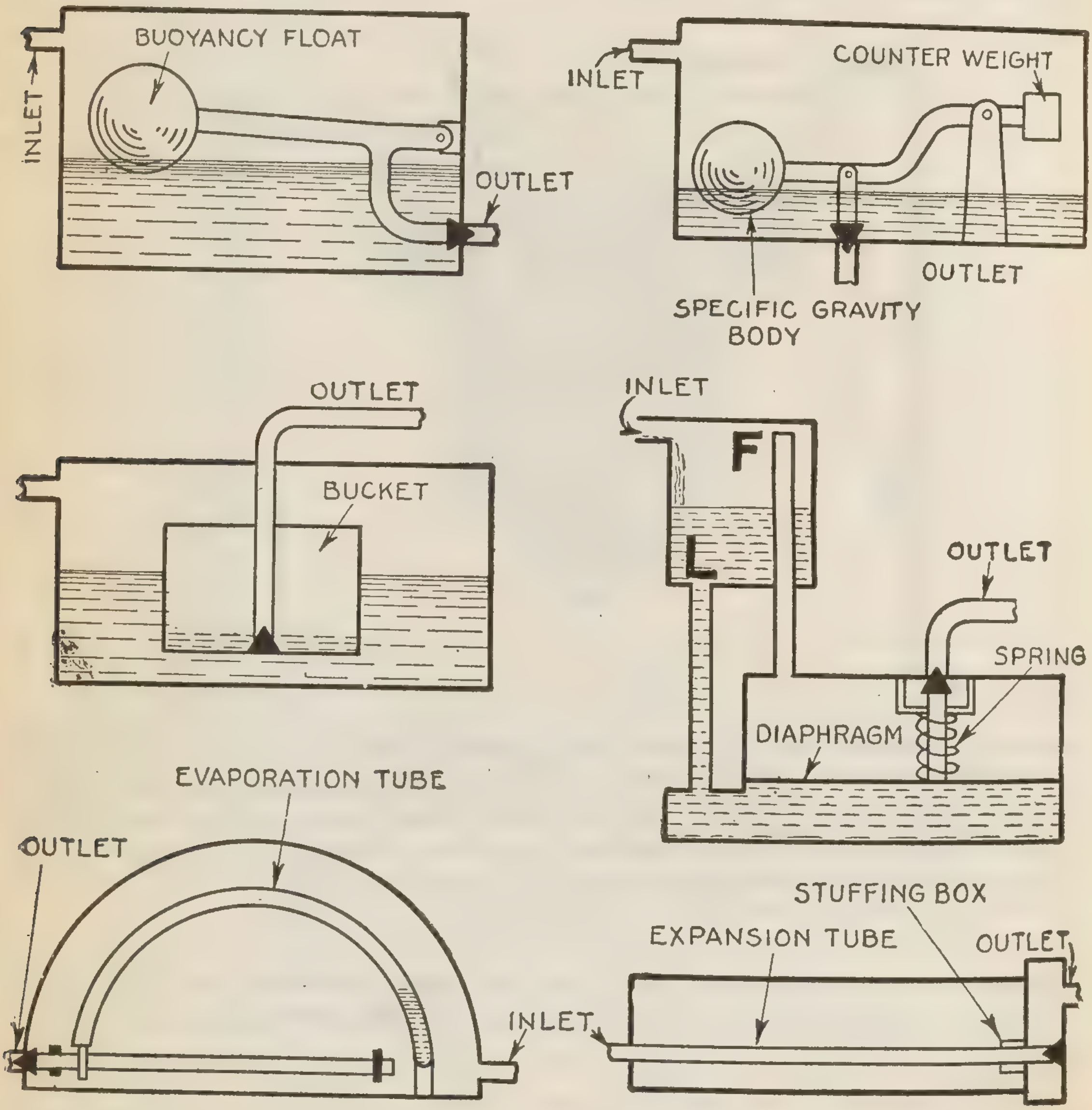
from the separator toward the boiler, the condenser being slightly inclined toward the drop leg so as to readily draw the condensate into the drop leg.

The condensate will accumulate in the drop leg to a height such that its weight will balance the weight of the mixture in the riser.

In order to proportion a steam loop properly by calculation, the specific gravity of the mixture in the riser should be ascertained, the difference of

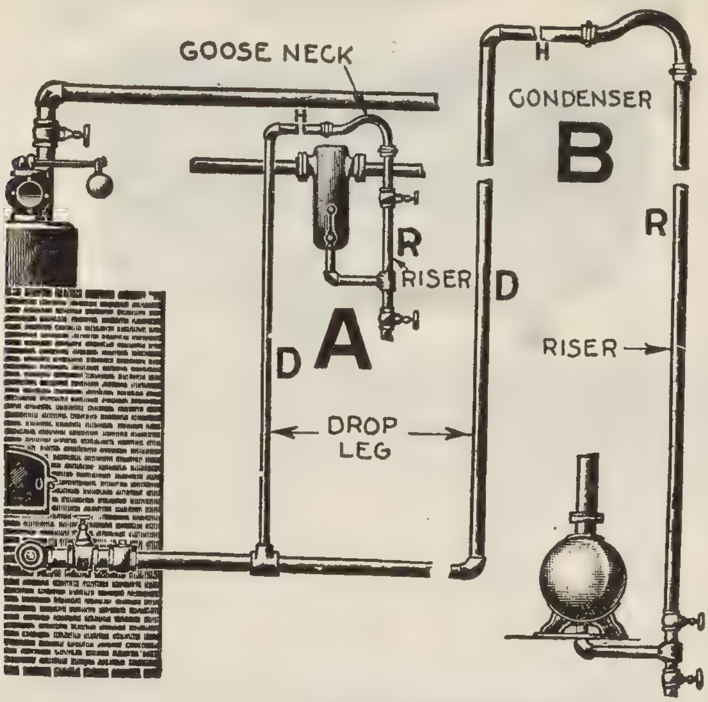
pressure between the boiler and the separator, and the pressure under which the system is to work, the latter quantity being used to determine the weight of water at the existing pressure and temperature.

Steam Traps.—By definition a steam trap is an *automatic device which allows the passage of water but prevents the passage of steam.*



FIGS. 8,186 to 8,191.—Elementary steam traps. Fig. 8,186, buoyancy float trap; fig. 8,187, counterweighted specific gravity body trap; fig. 8,188, bucket trap; fig. 8,189, differential trap; fig. 8,190, evaporation trap; fig. 8,191, expansion trap.

It is used in steam plants to automatically drain the pipes of condensate. According to Crane "a trap is a trap, and it is unfortunate that it is impossible to get along without them."



FIGS. 8,192 and 8,193.—Steam loop installation **A**, from separator; **B**, from drain reservoir located below the water level in the boiler. ***Example:*** If the difference of pressure between the separator and the pipe be, say, 2 lbs., then it will sustain a column of water at a temperature of 297° Fahr., equal to $2.509 \times 2 = 5.018$ ft. high. The riser, R, however, does not contain water alone, but a mixture of steam and water, the specific gravity of which varies, but may be taken as one-fourth that of water, about three-fourths of the volume being assumed to be steam. In that case the column sustained will equal $5.018 \times 4 = 20.072$ feet. Deducting 10 per cent. for friction, the net height of the riser pipe may be 18 feet. This applies to installation **A**. The calculation of installation **B** (fig. 8,193) is not so simple. Assuming in this case that there is a difference of 5 lbs. pressure between the top and bottom of the riser pipe, and that the lower point in the return system is 12 feet below the water level in the boiler; the same pressures and temperatures as before. If the loop be full of steam only, the water will rise in the drop leg, D, $5 \times 2.509 = 12.545$ feet to balance the difference in pressure. Adding this height to the required lift, it will be found that the top of the water column should stand $12.545 + 12 = 24.545$ feet above the bottom of the riser when the system is in equilibrium. Now, as the mingled water and steam in the riser pipe weigh more than the steam, the pipe must be lengthened still more; assuming the previous specific gravity of one-fourth that of water, this additional height will naturally be 24.545 feet $\div 3$ or 8.182 feet, one-fourth of the extra height being above the present level, and three-fourths below. Adding together 24.545 and 8.182 feet, the result gives 32.727 feet for total height of riser pipe, or subtracting the 12 feet lift, gives 20.727 feet as the height of the drop leg above the water level in the boiler.

NOTE.—A drip should be connected with the separator so as to drain the latter and the riser when they become filled with water, as will generally be the case after steam has been shut off for some time and the main piping has become partly filled with accumulated water.

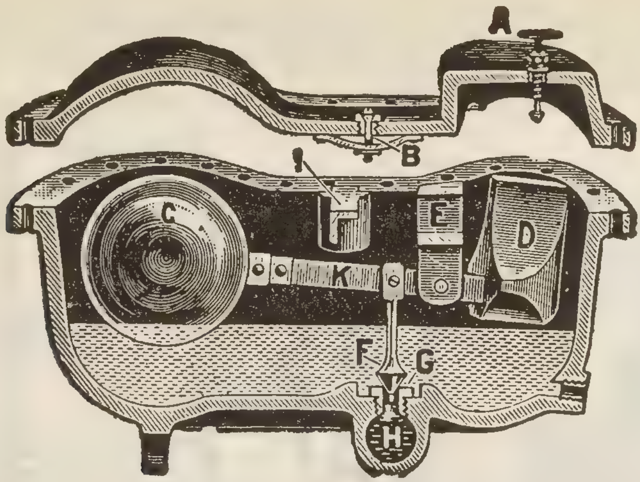


FIG. 8,194.—McDaniel ***counter-weighted specific gravity body*** steam trap. A, hand discharge; B, air vent; C, float D, counter-weight; E, fulcrum support; F, valve; G, valve seat; H, outlet; I, cross tie; J, tap for blow off valve; K, lever.

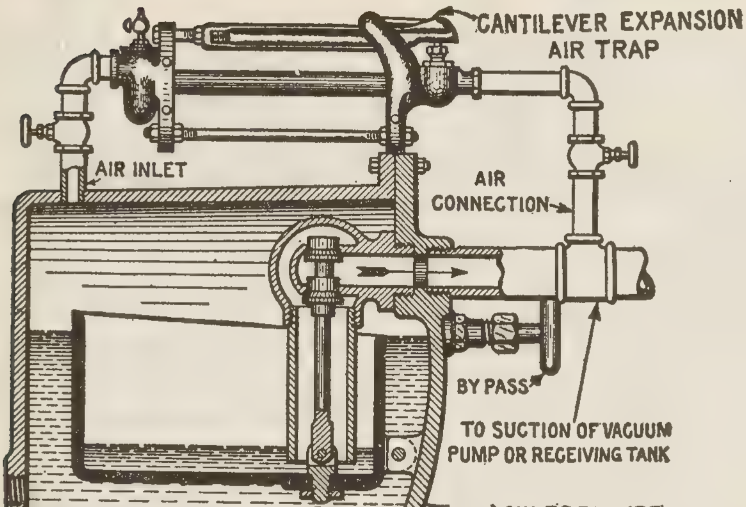


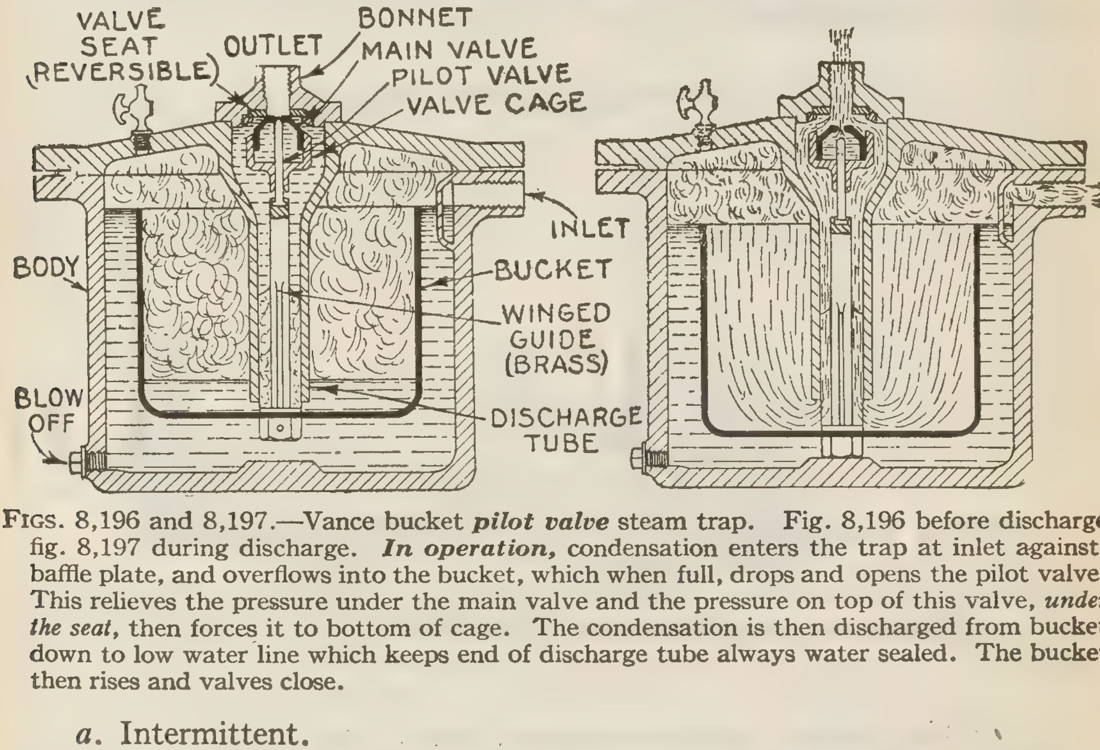
FIG. 8,195.—Kieley combination low pressure ***bucket*** trap with cantilever expansion air trap attached. The object in using a combination of this kind is to remove the air from the trap and heating system through the expansion air trap into the discharge. It is adapted to discharge water into the returns of a vacuum system.

There is an undue multiplicity of traps on the market (each one better than the other, according to the makers), and they may be classed:

1. With respect to the *disposition* of the condensate, as:

   a. Non-return.
   b. Return.

2. With respect to *nature* of operation, as:



FIGS. 8,196 and 8,197.—Vance bucket ***pilot valve*** steam trap. Fig. 8,196 before discharge fig. 8,197 during discharge. ***In operation,*** condensation enters the trap at inlet against baffle plate, and overflows into the bucket, which when full, drops and opens the pilot valve. This relieves the pressure under the main valve and the pressure on top of this valve, *under the seat,* then forces it to bottom of cage. The condensation is then discharged from bucket down to low water line which keeps end of discharge tube always water sealed. The bucket then rises and valves close.

   a. Intermittent.
   b. Continuous.
   c. Return.
   d. Non-return.

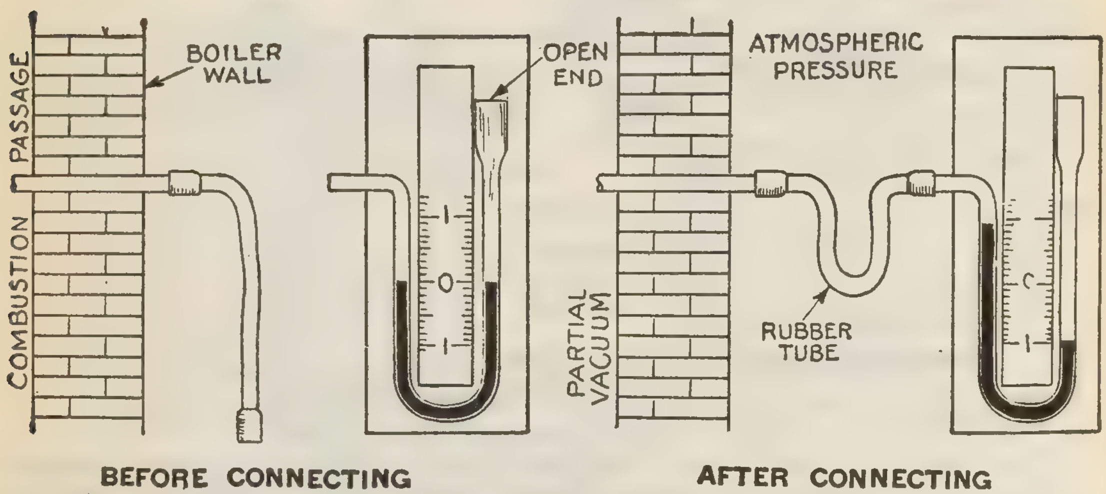
The terms *intermittent* and *continuous* are self-defining; they relate to the nature of the discharge from the trap. Most traps are intermittent, about the only working principle that will give approximately continuous discghare is that of *evaporation*.

Traps are said to be ***return,*** when they return the condensate to the boiler, and ***non-return*** when they do not return the condensate to the boiler.

Figs. 8,186 to 8,191, illustrate various principles employed in constructing steam traps.

In fig. 8,186 a light or buoyancy float at the end of a lever operates a valve controlling the discharge by the rise and fall of the condensate. The operation of the other traps is plainly shown in the illustrations.

Draught Gauges.—The draught or reduction of pressure in the combustion passages of a boiler is measured by the height of a column of water (or equivalent), which this difference of pressure will support.



Figs, 8,198 and 8,199.—U type draught gauge, at zero before connecting and indicating 2 inches draught after connecting. *In reading,* since the columns in the two tubes fall and rise equal distances, take the reading of one leg only and double it to obtain the draught in inches.

Fig. 8,198 shows a simple form of draught gauge called the U-gauge from its shape. It consists of a bent glass tube with adjustable scale and filled to the zero point with water.

One leg is open to the atmosphere and the other connected by rubber tubing and an iron pipe to the inside of the combustion passage at a point where it is desired to determine the draught. When thus connected, as in fig. 8,199, the greater pressure of the atmosphere pushes the water down in the open leg and up in the other until the difference in the heights of the

columns in the glass tube corresponds to the pressure difference between the atmosphere and hot gases in the combustion passage.

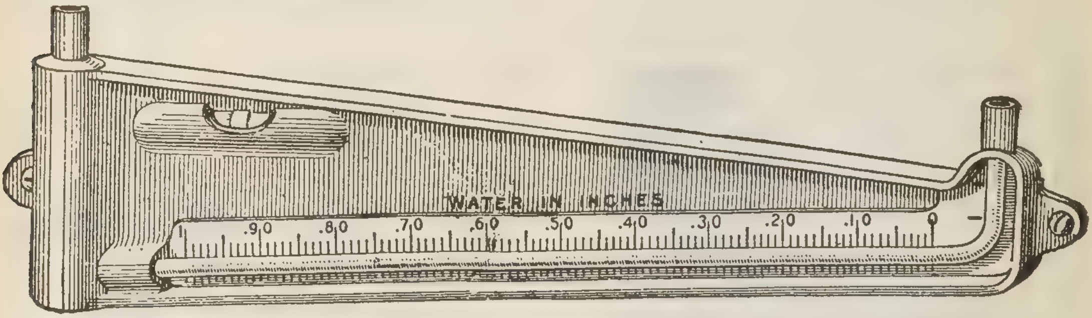


FIG. 8,200.—Inclined tube differential draught gauge. ***The fluid*** used is a special non-drying, non-evaporating oil of known specific gravity. The incline and diameter of the tube are so proportioned that the draught may be read direct to one hundredth of an inch in term of distilled water. The indications are taken on one leg of the instrument only, and the movement of the fluid is ten to one.

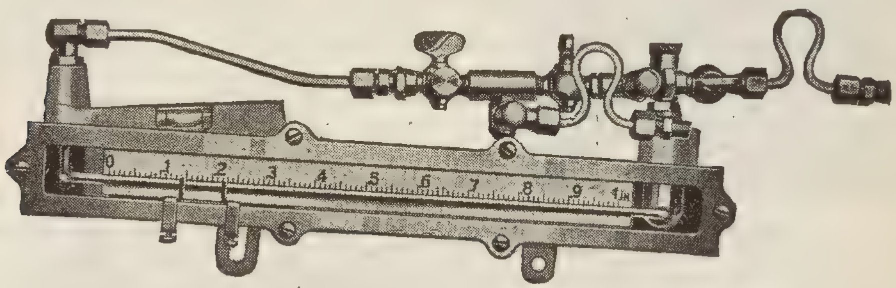
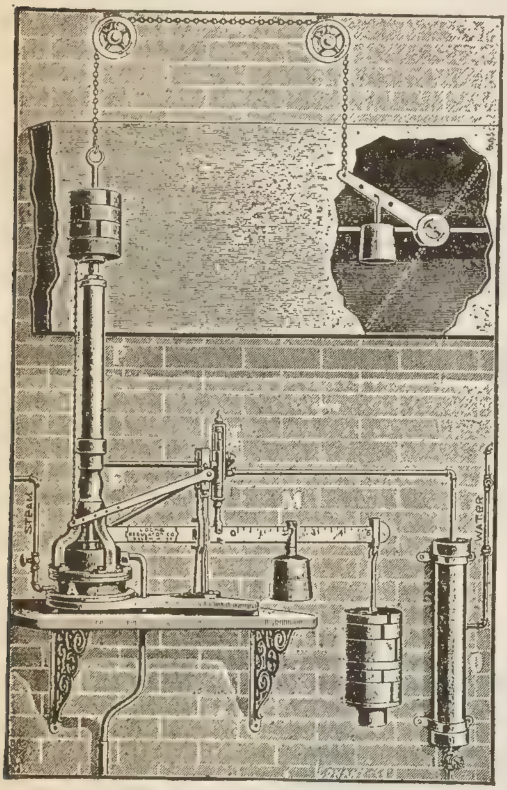


FIG. 8,201.—Ellison inclined tube combination differential draught gauge. With the style of cocks and cross piping, the furnace draught, flue draught, or differential between furnace and flue is independently indicated with the single tube. The furnace pointers are the first part and the differential pointer the second, all black except the high differential which is red. The differential ordinarily giving a wider liquid movement than the furnace draught, the gauge is so operated except momentarily on the furnace as a check or in case of excess soot in passages, indicated by too high readings. On the furnace, excess air through holes in the fire or thin bed causes the liquid to recede, whereas excess air by opening damper or increase in stack draught causes the liquid to advance. On the differential, excess air from any cause moves liquid forward only. Chamber connection is piped to the flue or over last pass, other connection to furnace. For differential readings, right and left cocks are open and middle cock is closed as shown. For furnace readings, right and left cocks are closed and middle cock is open, vent in left cock, slanting upward, open to atmosphere when closed. For flue readings, only the flue cock is open. Portable attachments are used for momentary pass readings or differential readings with furnace, connected with tee in chamber by removing plug. Where the low differential drop is only slightly over the high furnace pointer, second and third pointers can be brought close together by sliding them under from the other side of the clips or by holding both with one clip, taking one clip off. For lower drop, one or both furnace pointers are taken off. For high furnace draught and low drop, read drop between first hair, transposing second and fourth pointer, making second pointer red.

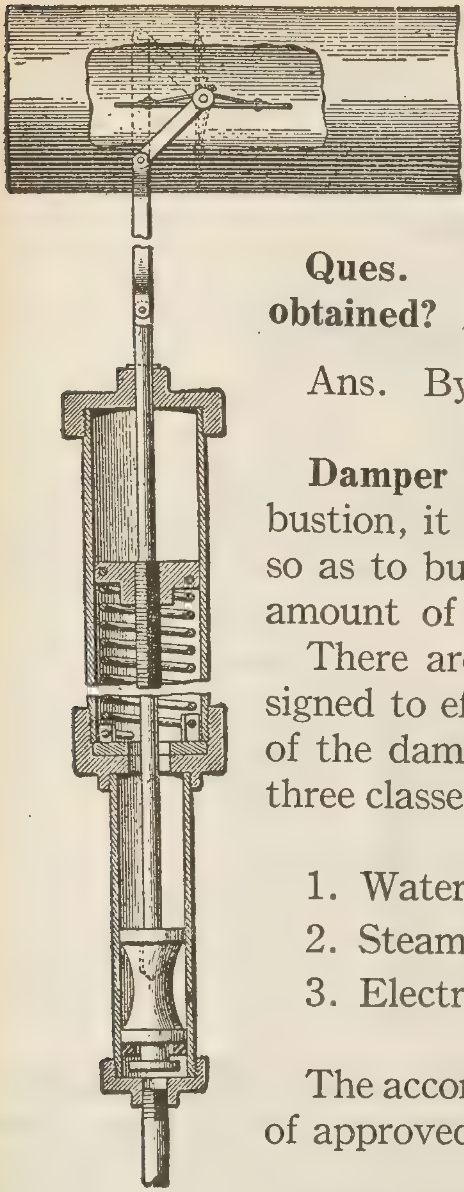
The instrument just described answers the purpose for occasional readings, but as a permanent fixture as for use in properly watching the draught a more reliable gauge is necessary.



Ques. What are the objections to the U gauge?

Ans. Since the gauge must be open to the atmosphere, the

FIG. 8,202.—Locke *hydraulic* damper regulator. ***In construction and operation,*** **A**, is the steam piston chamber connected by a ⅜ inch pipe with any steam pipe carrying full boiler pressure by which the regulator is governed, and should be placed where it will not feel the pulsation of the engine or pump. **P**, the water motor is utilized in controlling the damper, mechanical stoker, or forced draught, separately or combined as may be required. The water valve **I**, regulates the supply of water used in motor **P**. The stem of this valve is connected with, and actuated by, the scale beam **M**. Any attempt of the steam to rise above the pressure set for will raise this beam, admitting water to the motor, lifting the weights, partially closing the damper. Any attempt of the steam to fall is followed by a corresponding fall of the scale beam, closing the inlet valve to motor **P**, and opening the outlet, lowering the weights and opening or partially opening the damper, etc. **E**, is a lever which by means of a chain attached to motor **P**, operated a cam by which valve **I**, is moved, closing the same and checking the movement of motor **P**, and damper **H**, thereby preventing it going fully open or closed, and yet keeping it in just the place to maintain even steam pressure. The receiver or mud drum **D**, is used to permit any sediment which may be in the water to settle. The water supplied to motor **P**, should never be of a high temperature, and the cooler the better, and may be taken from any pipe convenient, carrying not less than 15 lbs. pressure. Motor **P**, is proportioned to suit the water pressure. Condensed water may be taken from the bottom of a steam pipe; a coil should be used for this purpose. A graduated scale beam **M**, by which the machine can be set quickly and accurately to any desired pressure, will be found a reliable and positive test for the gauges. Piston of motor **P**, control damper **H**, through chain and pulley transmission, when acted upon by water. Chamber **A**, contains no diaphragm, a rubber piston packing being used.



evaporation of the water renders the readings unreliable, moreover, the vertical column gives a scale too short for accurate readings.

Ques. How is a more extended scale obtained?

Ans. By inclining the tube as in fig. 8,200.

Damper Regulation.—For efficient combustion, it is necessary to regulate the draught so as to burn just enough fuel to generate the amount of steam required.

There are numerous forms of apparatus designed to effect automatic opening and closing of the dampers and they may be divided into three classes, according as they are operated by:

1. Water pressure.
2. Steam pressure.
3. Electricity.

The accompanying illustrations give examples of approved forms of the three classes.

FIG. 8,203.—Tilden ***steam*** damper regulator. ***It consists of*** a brass cylinder in which is a piston connected to a spring, which balances the steam pressure. Condensed steam from the boiler is admitted under the piston, and being pure water, contains nothing that will corrode the parts and no grit or impurities to cause the piston to stick. Since the spring is in a separate chamber, no steam or water can come in contact with it, and there is no condition present that will change its strength or alter its movement. Steam is admitted to the pipe, seen at the bottom of the figure, and any variation in pressure results in a movement of the piston and rod so that the damper is opened or closed in proportion to the change in pressure. Connection is made direct, as shown in the illustration where this is possible, but if not, a rocker shaft made of ¾-inch piping may be used to transmit the motion.

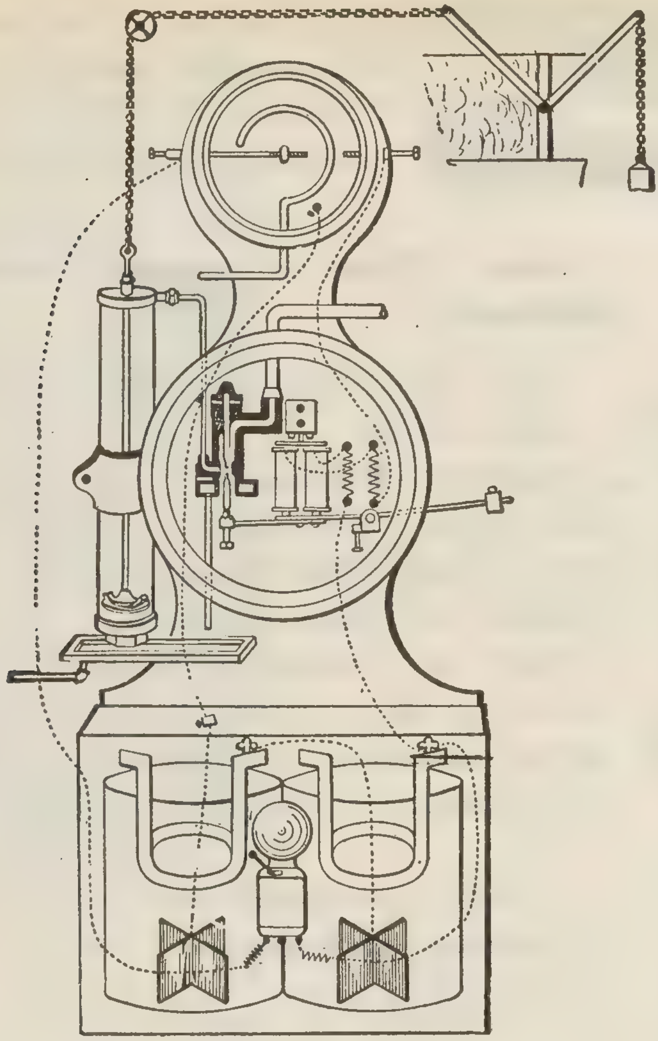


FIG. 8,204.—McDonough *electric* damper regulator. ***In construction,*** there are two pieces in the casing of the steam gauge (seen at the top of the cut), which are screwed in so that they touch the expanding pipe coil when the pressure rises or falls to the point for which it is desired the apparatus shall operate. When the spring touches one of these pins, an electric circuit is closed and the electromagnets in the case at the bottom of the apparatus are energized so that they lift the armature and open the valve, thus admitting water to the cylinder and forcing the piston down, so as to close the damper. When the steam pressure falls, the spring coils up and, in so doing, touches the other pin, thus making a second electric circuit and operating other electromagnets to ring an alarm bell.

CHAPTER 123

Pipe Fitting

The term "pipe fitting" includes the operations which must be performed in installing a pipe system as made up of pipe and fittings. These operations consist of:

1. Pipe cutting.
2. Pipe threading.
3. Pipe tapping.
4. Pipe bending.
5. Assembling.

The mechanic who performs the work of pipe fitting is called a *pipe fitter*, and sometimes a *steam fitter*, because the work is largely connected with steam installations. Considerable experience is necessary to become a good pipe fitter, and there are a good many persons engaged in this occupation who do not deserve the title of steam fitter.

Pipe Cutting.—Wrought pipe as received from the manufacturers, comes in lengths varying from 12 to 22 feet, and in "pipe fitting" it is frequently necessary to cut it to any particular length that may be required. This may be done with a hack saw or a pipe cutter, the pipe in either case being put in a pipe vise, as shown in fig. 8,205.

In securing the pipe in the vise, care should be taken (especially when threading) that the jaws hold the pipe sufficiently firmly to prevent slipping, but the clamp screw should not be turned enough to cause the jaw teeth to unduly dig into the pipe.

A pipe cutter may be defined as an instrument usually consisting of a hook shaped frame on whose stem a slide can be moved by a screw. On the slide and frame several cutting discs or "wheels" are mounted and forced into the metal as the whole appliance is rotated about the pipe.

Pipe cutters may be classed as:

1. Wheel.
2. Combined roller and wheel.
3. Knife.

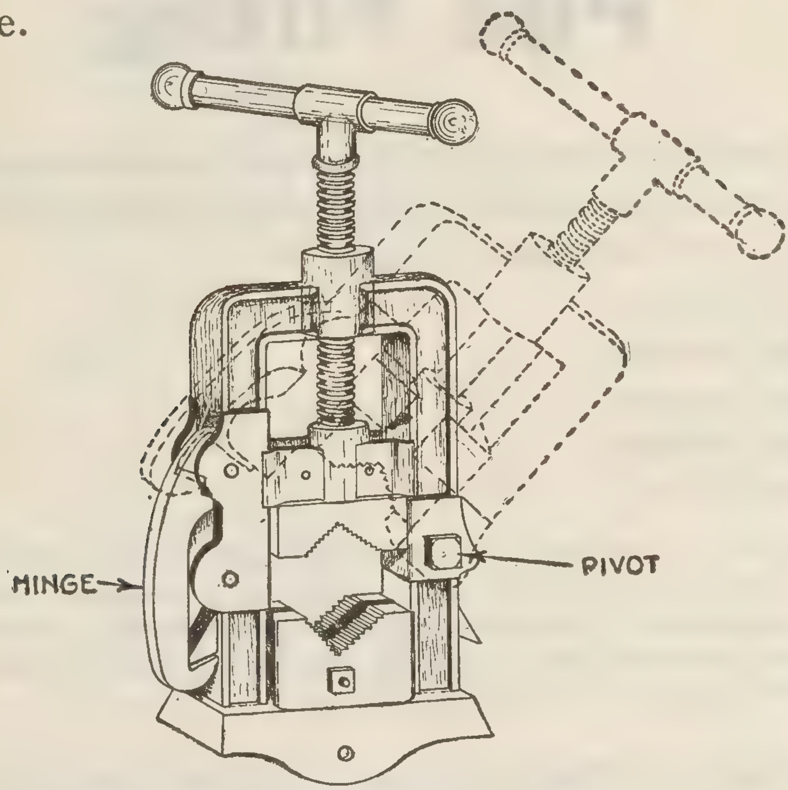


FIG. 8.205—Ordinary pipe vise. ***It consists of*** a plain, or hinged (as shown) U-shape piece containing the clamp screw, the sides of which form guides for the upper jaws. The upper and lower jaws are provided with a series of rectangular teeth as shown. When the U piece is closed over the pipe, pin inserted, the teeth of both jaws are brought in firm contact with the pipe by screwing down the upper jaw thus holding the pipe firmly.

The operation of cutting a pipe can be done quicker with a pipe cutter than a hack saw, and for this reason the former is more frequently used, although it crushes the metal and leaves a shoulder on the outside and a burr on the inside of the pipe. This does not apply to the knife type of pipe cutter. The

appearance of the cuts made with hack saw and pipe cutter is shown in figs. 8,211 to 8,213.

The external shoulder must be removed to allow the pipe to

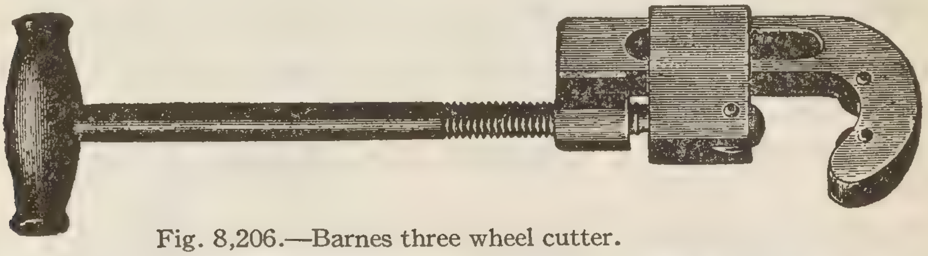
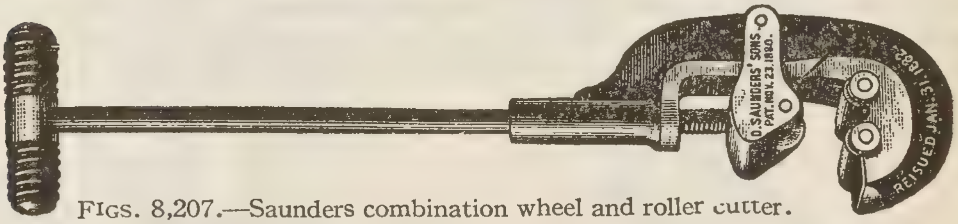


Fig. 8,206.—Barnes three wheel cutter.



FIGS. 8,207.—Saunders combination wheel and roller cutter.

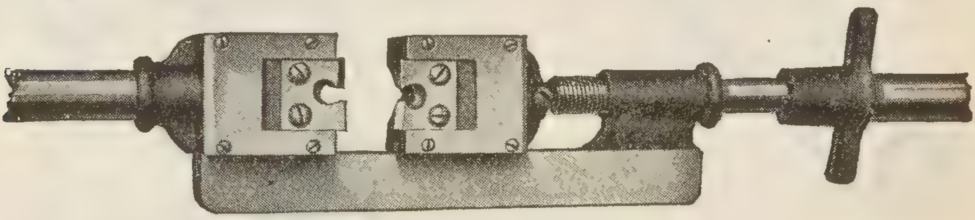
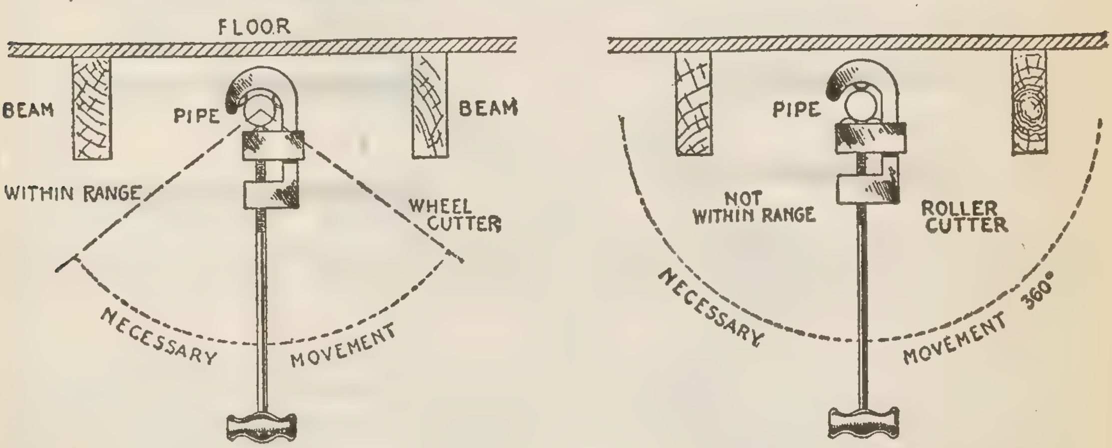


FIG. 8,208.—Beaver knife cutter.



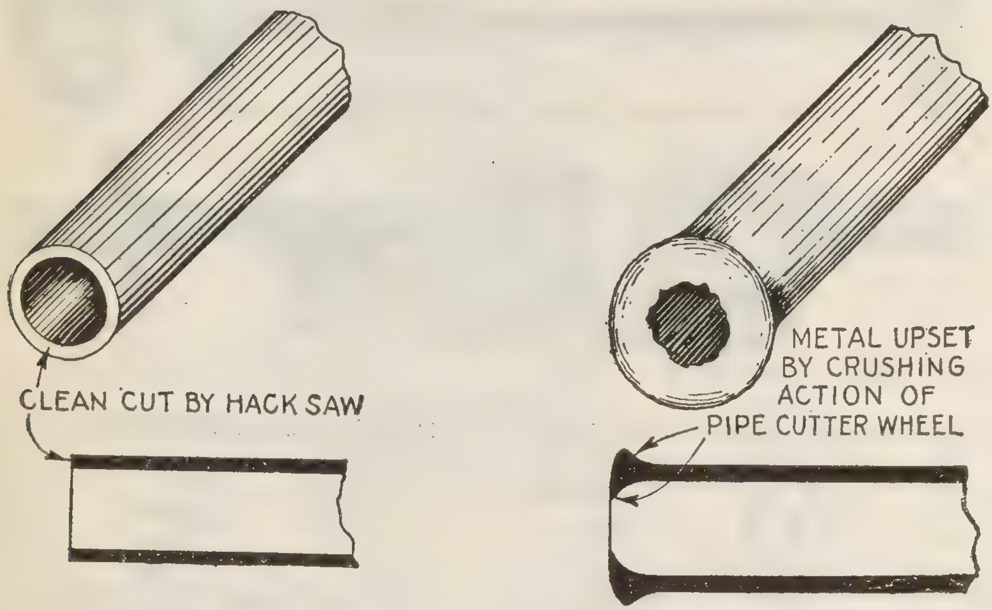
FIGS. 8,209 and 8,210.—Three wheel cutter and combined wheel and roller cutters illustrating ***range.*** The cuts show the comparative movements necessary with the two types of cutter to perform their functions. The three wheel cutter requiring only a small arc of movement, will cut a pipe in an inaccessible place as shown, which with a roller cutter would be impossible. Accordingly, the wheel cutter is said to have a greater ***range*** than the roller cutter and is therefore to be preferred for general work.

enter the threading tool so no worry need be given that the workman will not do this, but *it should be ascertained* ***by inspection*** *that the internal burr is removed on every cut*, especially on plumbing jobs, to avoid future trouble with clogged pipes.

Figs. 8,206 and 8,207 show two types of wheel cutter the latter being a combined wheel and roller cutter; figs. 8,208 shows a knife cutter.

The one wheel cutter is adapted more for shop use than for general work.

The three-wheel cutter shown in fig. 8,206 is in the author's opinion the best type cutter on the market for general work. With this cutter, the work of cutting is distributed among the three wheels, whereas with the form shown in fig. 8,207, one wheel has to do all the work.



FIGS. 8,211 to 8,213.—Appearance of pipe end when cut by hack saw, and by pipe cutter. When a pipe cutter is used the internal burr must be removed by a burring reamer as in fig. 8,215, and the external burr by a file as in fig. 8,216.

Although the rollers insure a straight cut, a little care in starting a three wheel cutter is all that is necessary to obtain a straight cut, moreover, the *range* of work possible with a three wheel cutter is greater than that with a one wheel or combined roller and wheel cutter, as illustrated in fig. 8,210. When the wheels become dull or nicked they are easily removed and renewed at nominal expense.

The knife cutter makes a clear cut like a hack saw but is a more expensive tool than the other types.

Too much attention cannot be given to removing burrs produced by wheel cutters because the burr usually has a ragged and sharp edge, which catches any sediment or other foreign matter passing through the pipe and finally stops the flow. It must be evident also that at the outset the burrs reduce the

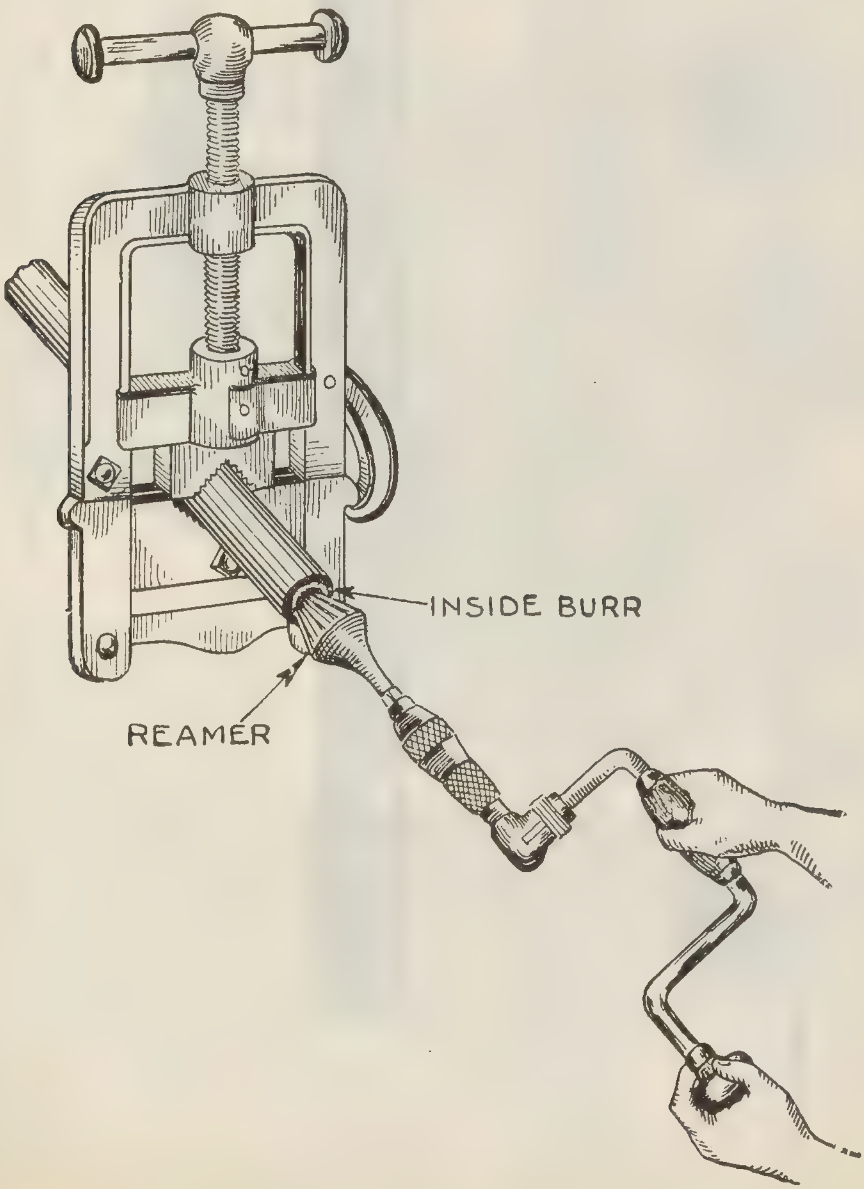
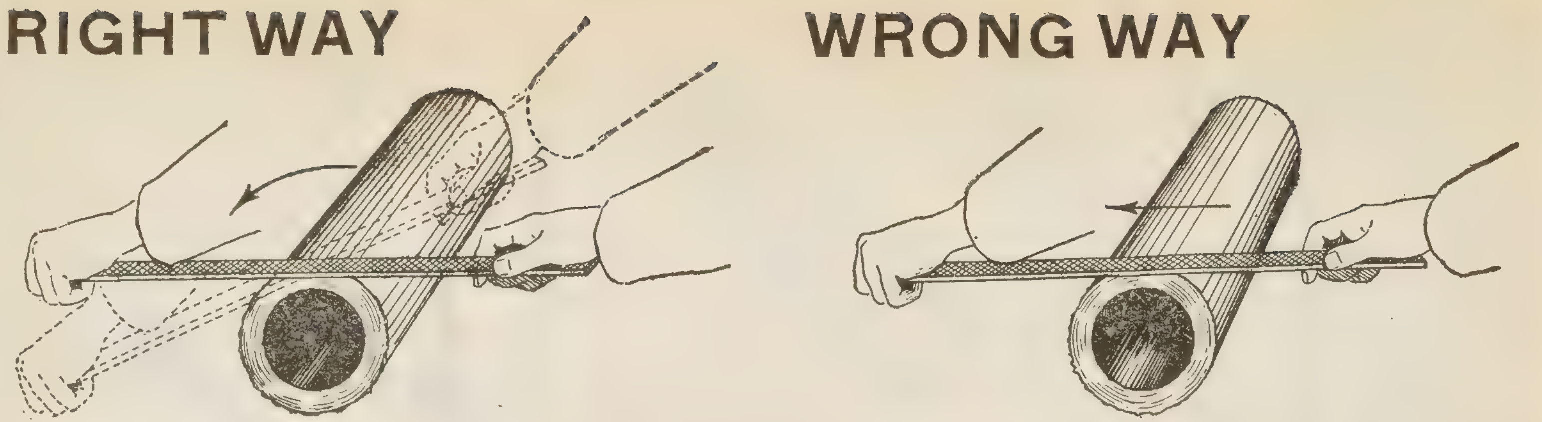
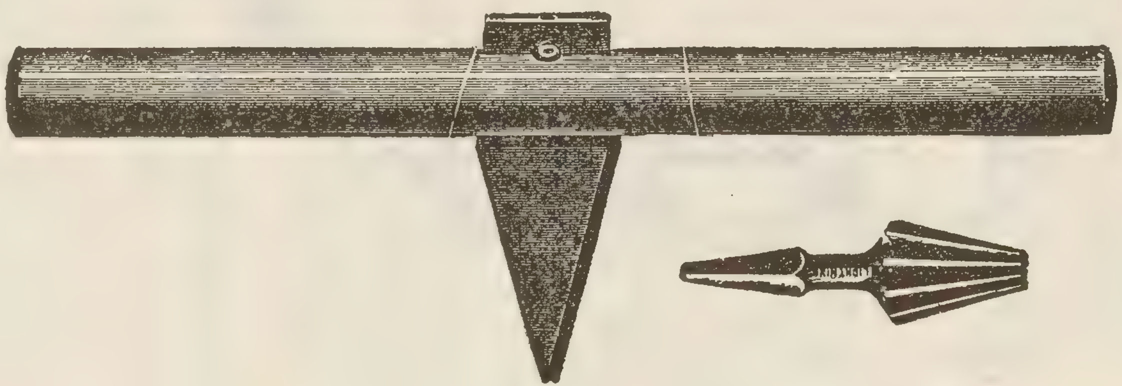


FIG. 8,215.—Method of removing burr from pipe end with brace and a burring reamer.



FIGS. 8,216 and 8,217.—***Right*** and ***wrong*** way of removing the shoulder left on pipe and after cutting with a pipe cutter. Obviously at each stroke, the file should be given a turning motion as indicated by the arrow and dotted position in figure 8,216, removing the excess metal through an arc of the circumference. The position of pipe is changed in the vise from time to time, till the excess metal is removed all around the pipe. When the operation is done, as in fig. 8,217, by moving the file in a straight line, it will result in a series of flat places.



FIGS 8,218 to 8,219.—Various burring reamers for removing burrs from pipe ends after cutting. Fig. 8,218, Hall patent reamer; fig. 8,219, reamer for use with brace.

sectional area of the pipe and thus increase the friction to flow. The proper and convenient way to remove a burr is by a brace and burring reamer, as shown in fig. 8,215.

Pipe Threading.—Having cut the pipe to proper length, filed off the outer shoulder and reamed out the burr, it is now ready for the threading operation. The Briggs threads may be

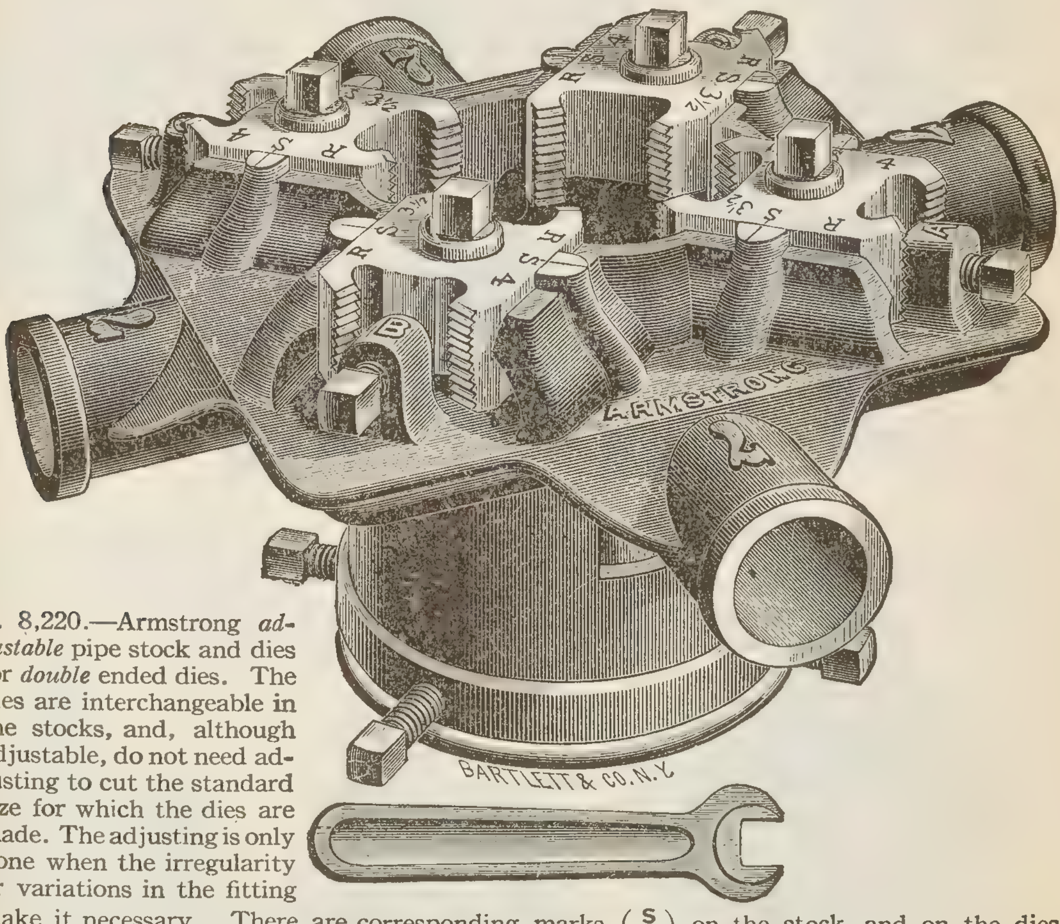


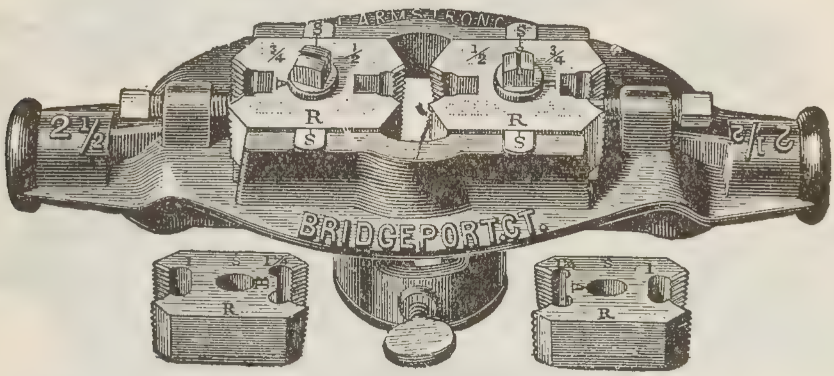
FIG. 8,220.—Armstrong *adjustable* pipe stock and dies for *double* ended dies. The dies are interchangeable in the stocks, and, although adjustable, do not need adjusting to cut the standard size for which the dies are made. The adjusting is only done when the irregularity or variations in the fitting make it necessary. There are corresponding marks $\left(\begin{smallmatrix}S\\I\end{smallmatrix}\right)$ on the stock and on the dies $\left(\begin{smallmatrix}I\\S\end{smallmatrix}\right)$ and when these marks are brought into line the dies will cut the standard size. The No. 2 set shown above can, by purchasing extra dies and bushings, be used also to thread bolts and brass tubing or fine thread dies.

cut on the pipe ends for screwing into the fittings either by means of

1. Hand stock and dies, or
2. Pipe threading machines.

The hand stock and dies being portable, are generally used for small jobs, especially for threading pipe of the smaller sizes, although there are some geared forms suitable for large work without undue physical effort; the threading machines are for use in shops where a large amount of threading is done. Hand stock and dies may be classed with respect to the dies, as

1. Solid.
2. Sectional.

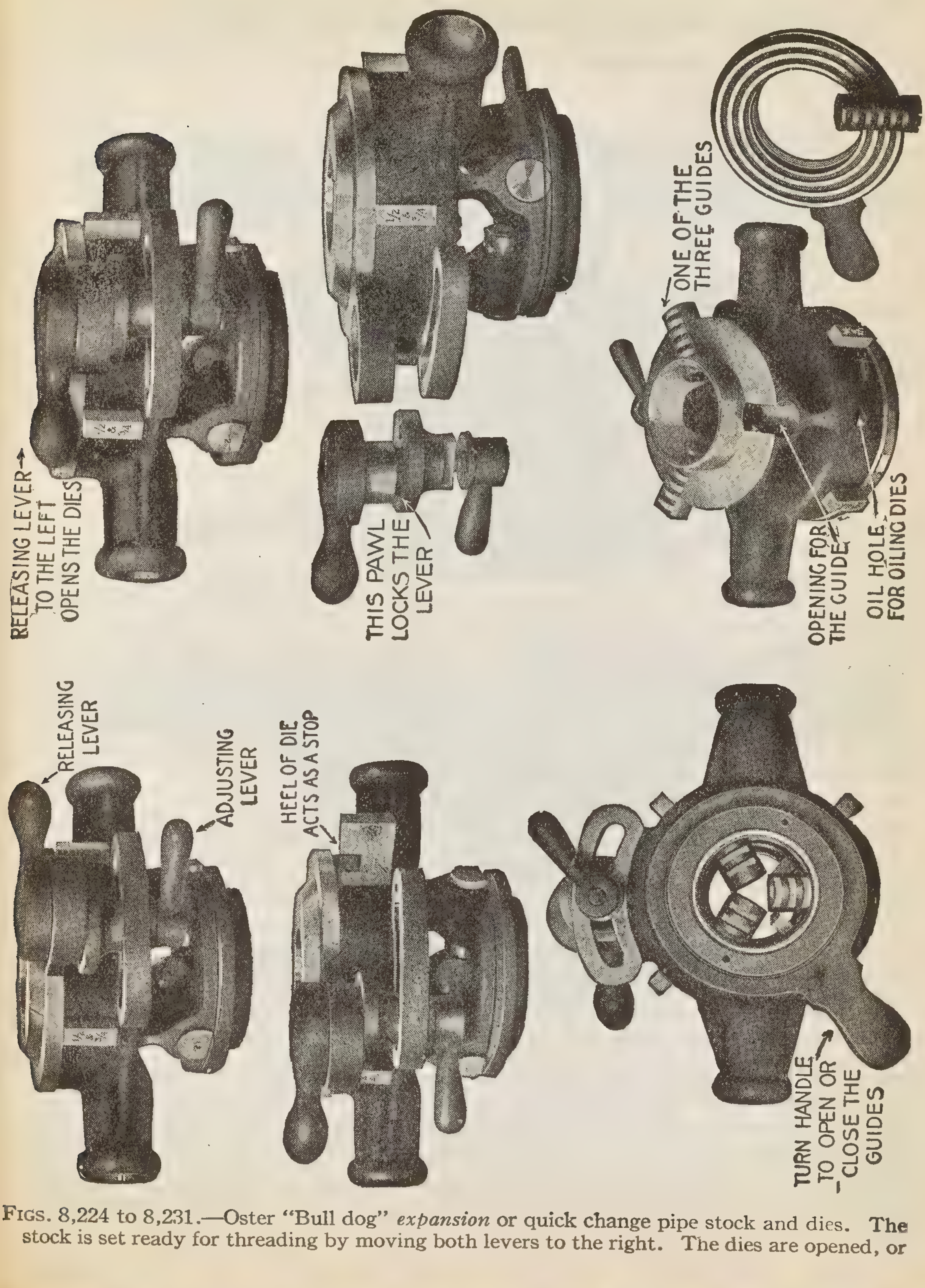


FIGS 8,221 to 8,223.—Armstrong *adjustable* pipe stock and dies for ***double*** ended dies. Each pair of dies, as shown, have one size thread at one end and another size at the other. Thus the two dies in the stock are in position for cutting ½-inch thread and by reversing them they will cut ¾-inch thread. The cut shows plainly the reference marks which must register with each other in adjusting the dies to standard size by means of the end set screws.

3. Adjustable.
4. Expanding.
5. Receding.

The accompanying illustrations show these various types. In use, the dies are placed in them and are adjusted to the variations in the size of fittings by the set screws at the ends and secured by the bolts which pass through the dies, the holes in the dies being sufficiently larger than the bolts to allow the necessary lateral adjustment movement.

The term ***expanding*** is used to represent that class of threader in which one set of dies is used for all sizes of pipe having the same number of threads, the dies being moved closer or farther apart by means of cams or equivalent. Since only five different thread pitches are used in the entire range of pipe sizes. the advantage of this in adapting a stock for quick change is apparent.



FIGS. 8,224 to 8,231.—Oster "Bull dog" *expansion* or quick change pipe stock and dies. The stock is set ready for threading by moving both levers to the right. The dies are opened, or

The following table shows the range of sizes for each thread:

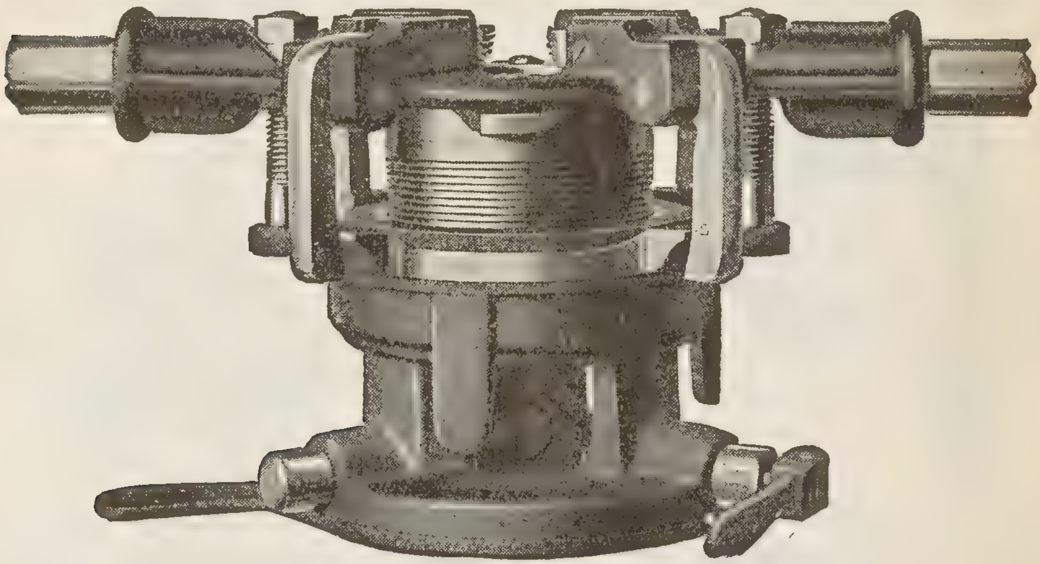
Number of threads per in.	Pipe sizes ins.
27	⅛
18	¼, ⅜
14	½, ¾
11½	1, 1¼, 1½, 2
8	2½ and above.

From the table it is seen that with two sets of dies cutting 18 and 14 threads, four pipe sizes (¼, ⅜, ½ and ¾), can be threaded, and with a set cutting 11½ threads 1, 1¼, 1½ and 2 in. pipe can be threaded. All that is necessary is to provide the stock with mechanism for quickly and properly spacing the dies to correspond with the different pipe sizes. A stock having these features is shown in figs. 8,224 to 8,231.

FIGS. 8,224 to 8,231—*Text continued*

closed by one movement of the releasing lever. The dies are changed from one size to another; or set for over or under size, by movement of the adjusting lever. The size is determined by the dies and the graduated marks on the face of the tool. The face of the stock is entirely free of gauges to regulate the size; or friction devices to hold the dies. In fig. 8,224, the releasing lever is thrown to the extreme left, this throw expands the dies so they will clear the thread and the stock can be lifted off without backing over the finished thread. The dies are reset to size, ***without looking at the marks,*** by simply bringing this lever back to the extreme right. ***Note that the lower adjusting lever is not touched.*** The lower lever is the lock nut, or adjusting lever, used in locking the die cam. This lever is moved along the slot until the graduated marks on the face of the tool show the desired size. Then one turn of the adjusting lever to the right will hold the dies secure while threading. This lock nut is used only when changing from one *size* to another, or when *changing the dies*. Fig. 8,225 shows both levers moved to the left to the limit of travel. The dies are now released and can be removed outward through the stock; they are here shown partly withdrawn. They will enter the stock in the same manner until the die strikes a stop. Then after the top lever is turned to the right, the dies are locked in the stock ready to reset to size. They cannot fall out. The heel of the dies is 1/16-inch higher than the front, which acts as a stop, and brings the dies into engagement with the cam. Thus, when all are in as far as the stop will permit, all are simultaneously caught by the lever. Figs. 8,226 and 8,227 show setting post and stock, setting post removed, to show pawl which locks the lever. ***The upper lever*** is the releasing lever used only to expand the dies sufficiently to free the thread without backing off. It is eccentric in form, and a spring pawl is provided which holds the lever in position. The pawl acts as a stop for the extreme right, or left position. ***The lower lever*** is the lock nut, or adjusting lever, used in locking the die cam. This lever is moved along the slot until the graduated marks on the face of the tool show the size it is desired to thread. Then one turn of the adjusting lever to the right will hold the dies secure while threading. This lock nut is used only when changing from one size to another, or when changing the dies. Figs. 8,228 to 8,230 show guide mechanism; fig. 8,231 showing the scroll which operates the guide. In this view, one guide has been removed from the stock to show how the spiral screw draws these jaws up to register with the diameter of the pipe.

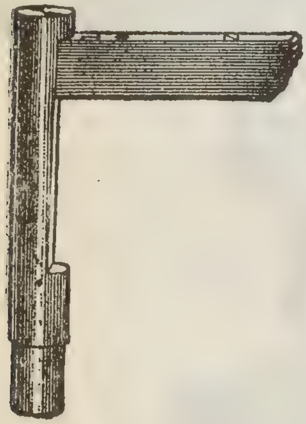
The ***receding*** form of threader employs tapered posts or levers against which the back ends of the dies rest. In cutting a thread, the dies at the beginning of the operation cut a full depth thread. As the work progresses

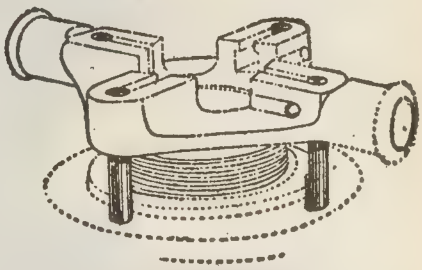


Figs. 8,232 and 8,233.—Greenfield ***receding*** pipe threader *lever form*. Fig. 8,232, position of threader when ready to thread; fig. 8,233 position of threader when cut is finished. To avoid unwinding the lead screw, three conveniently placed lugs are provided, a turn of any one of which disengages the lead screw, so that the head may be lifted or pulled straight back to original position, and reset there. The threader has a three jaw universal chuck guide. After the jaws are tightened against the pipe, one turn of the grip screw working inside of a chuck jaw completes the bite, firmly gripping the pipe. The threader is adjustable for shallow or deep threads, adjustment being made by changing the setting of the lock nut and adjusting rods that project through the head of the threader.

(taking the lever type for illustration), the levers which support the dies gradually change their position, permitting the dies to ***recede*** until they have finally backed completely away from the pipe. The stock can then be pulled straight off the pipe, thus avoiding unwinding or backing off.

Figs. 8,232 and 8,233 show the lever type of receding threader, and fig. 8,234 to 8,236 the tapered pin type.





FIGS. 8,234 and 8,235.—Detail of Toledo ***receding*** pipe threader, *tapered pin* form. ***In operation*** the dies are slipped into their respective slots and pushed back until they rest against the flat tapered surface of the posts. Fig. 8,234 shows one of these posts or "taper pins," and a die resting against it in proper position in the beginning of the operation of cutting a thread. During the cutting operation the die works down on these taper pins allowing the cutting teeth to recede, thus producing the tapered thread. Shallow or deep threads may be cut by varying the position of the die on the taper pins.

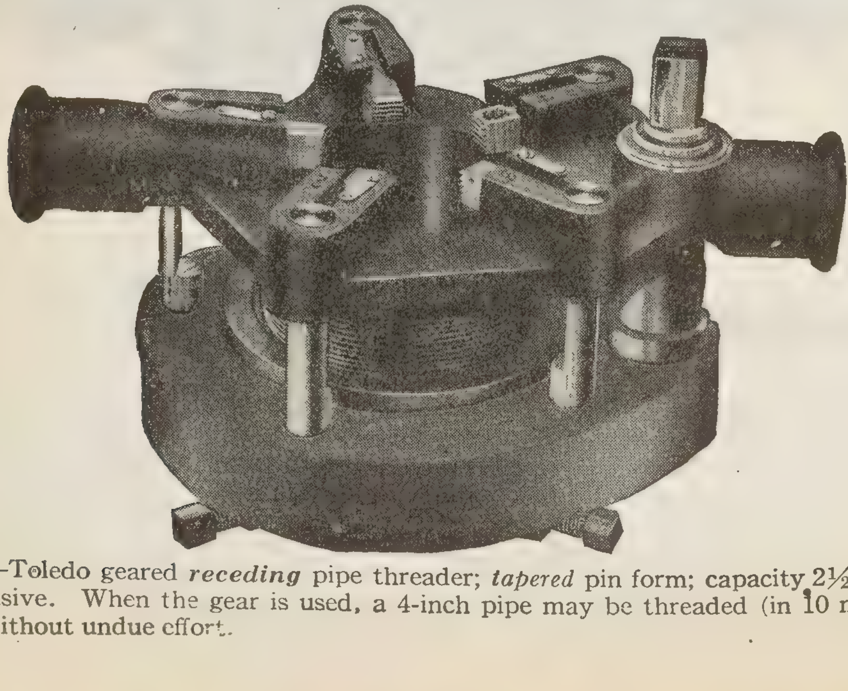
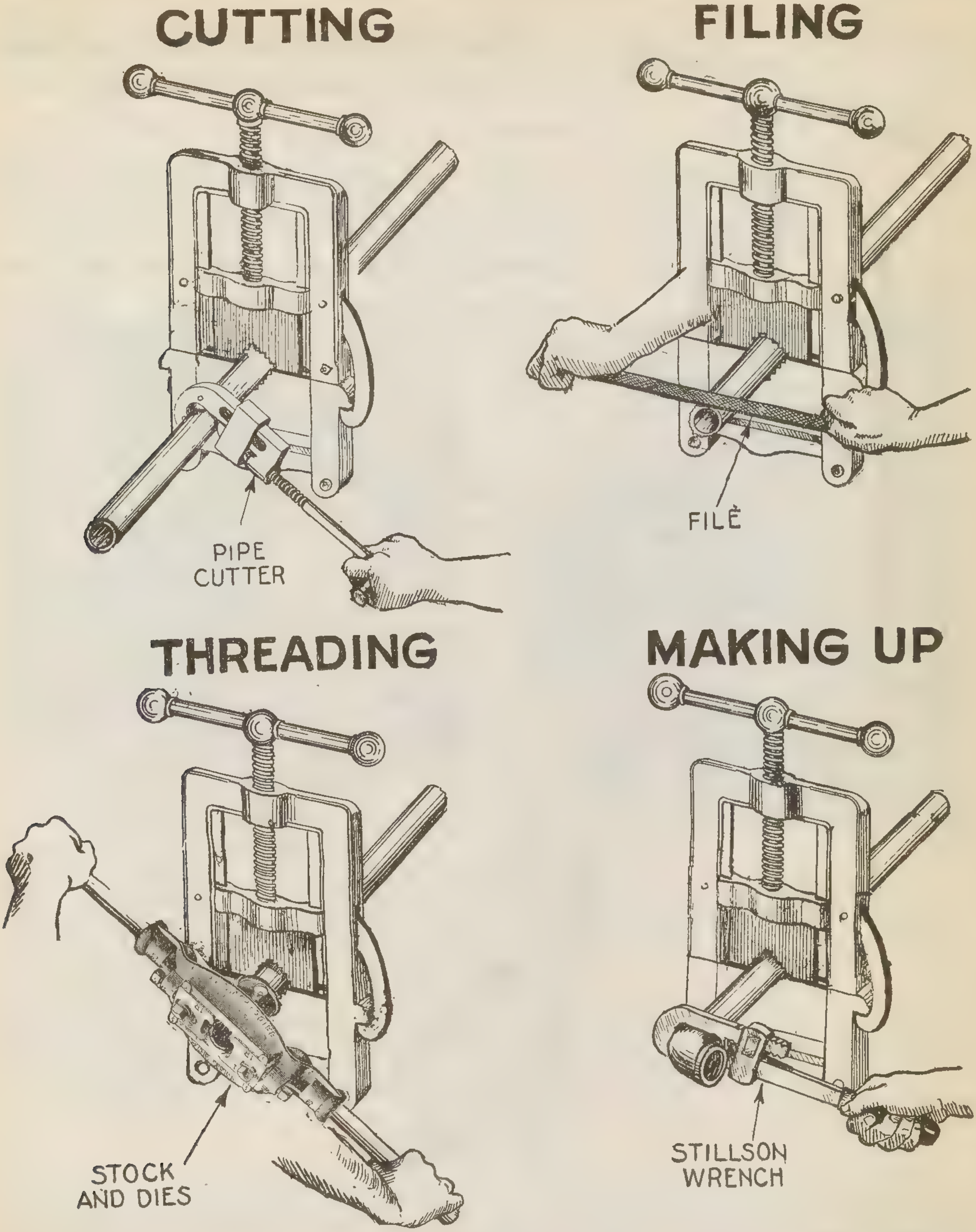


FIG. 8,236.—Toledo geared ***receding*** pipe threader; *tapered* pin form; capacity 2½ to 4 inch pipes inclusive. When the gear is used, a 4-inch pipe may be threaded (in 10 minutes as claimed) without undue effort.



FIGS. 8,237 to 8,240.—Principal operations in pipe fitting. The pipe after being marked to length by nicking with a file is put in use and cut with pipe cutter (or hack saw) as in fig. 8,237; burrs, removed with file as in fig. 8,238. Next the thread is cut with stock and dies as in fig. 8,239 and *after carefully cleaning thread with hard tooth brush*, and applying red lead or pipe cement to thread just cut, the joint is made up with a Stillson wrench as in fig. 8,240.

Ques. Describe the proper method of cutting a thread with stock and dies.

Ans. Use plenty of oil in starting and cutting the thread. In starting press the dies firmly against the pipe end until they "take hold." After a few turns blow out the chips and apply more oil. This should be done two or three times before completing the cut. When complete blow out chips as clean as possible and back off the die. Avoid the frequent reversals usually made by some pipe fitters.

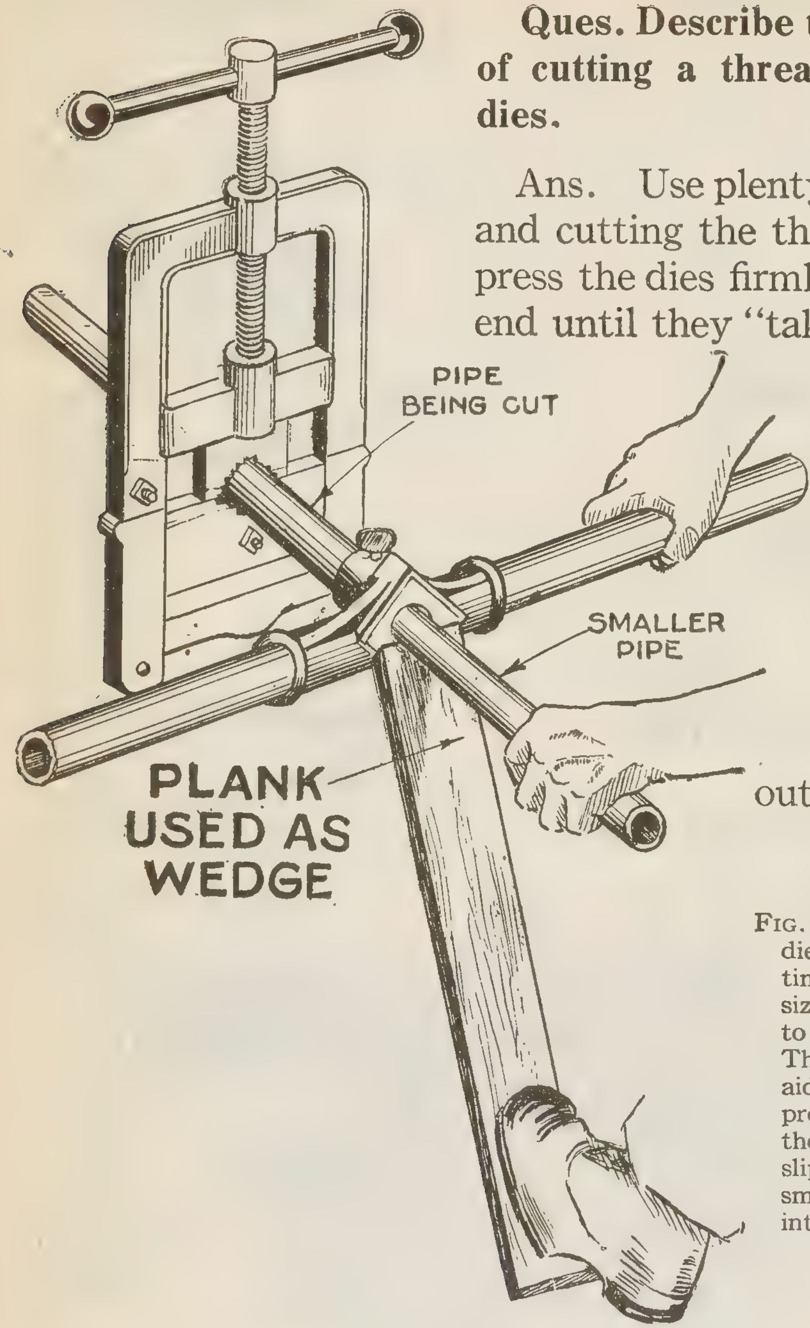


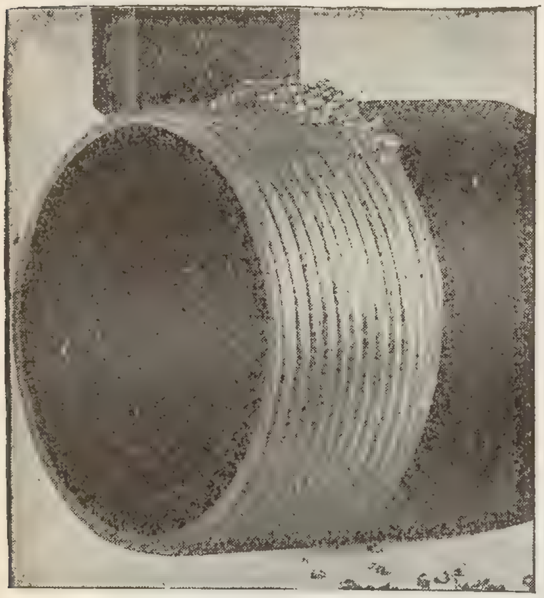
FIG. 8,241.—Method of starting die on hard thread. Sometimes owing to irregularity in size of pipe or die it is hard to start the die in threading. This may be easily done with aid of a plank as wedge, pressing against die as shown, the plank being prevented slipping across the die by the small pipe which is telescoped into the pipe being cut.

For lubrication, lard will be found preferable to oil. Apply the lard to the pipe end with a brush. In cutting the thread, the heat generated will

melt the lard which will flow to the cutting edge of the die giving continuous lubrication instead of spasmodic flooding as is the case when using oil.*

Flat Threads.—A considerable amount of material is discarded on account of the threads being a trifle flat, and such practice may be regarded as due to ignorance.

With a little reasoning it must be evident that the entire thread must be



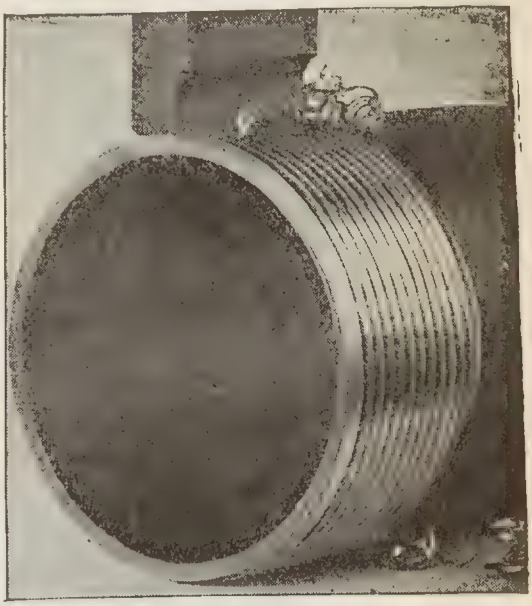
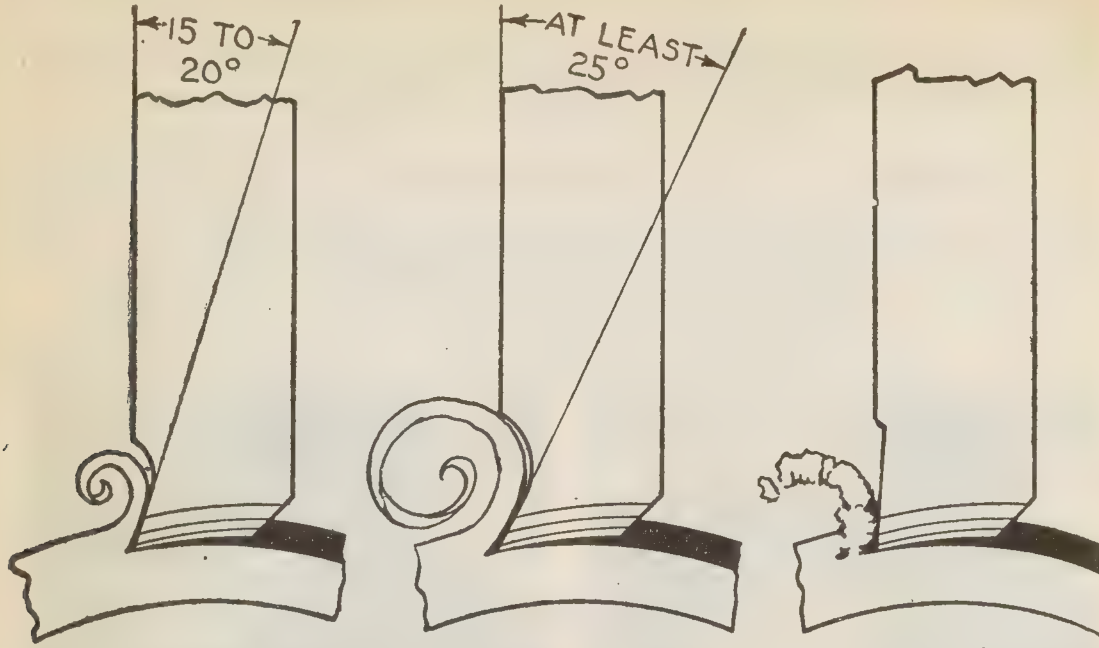


FIG. 8,242.—Thread cut with wrongly shaped but commonly used die. ***All pipe fitters*** are familiar with this pretense for a thread and no doubt wonder what makes the joint tight. The manufactureres are not to blame; they are simply trying to make their tools fool proof, as with the exception of the so called "monkey" wrench, pipe dies probably receive the greatest amount of abuse. A die having a radial cutting edge, as in fig. 8,242, does not cut but pushes the metal out, or tears it up by the roots.

FIG. 8,243.—Thread cut with properly shaped die. ***The chief points*** of a properly shaped die are: 1, correct *rake* or cutting angle obtained either by pitching the chaser above center or grinding the cutting edge; 2, sufficient *relief*, so that the cutting edge of the die will bear on the pipe; 3, enough chip clearance to avoid clogging, the lack of which often results in stuffing the thread.

flat in order to cause a leak, and then the leak must traverse the circumference of the pipe as many times as there are threads in contact. Now it might be possible to have a leak under these circumstances if no red lead

*NOTE.—The author is indebted to Mr. Harbison, thread expert of the National Tube Co., for this suggestion.



Figs. 8,244 to 8,246.—***Lips.*** Fig. 8,244 shows a chaser properly lipped for cutting ordinary steel pipe, the angle line showing how the lip should be ground. Care should be taken when sharpening the face of the chaser to maintain a good cutting angle of from 15 to 20° as shown. Gringing back the face of the chaser does no harm if properly done. Fig. 8,245 shows a die lipped for cutting open hearth steel pipe, which requires a long, easy lip on account of the tough character of material. For open hearth steel the lip angle should be 25°. Fig. 8,246 shows the ordinary form of commercial die which is unsuitable for cutting, not only steel but also wrought iron. The lip angle is insufficient. This type of chaser requires excessive power to cut the thread and the result is that the metal is pushed off instead of being cut.

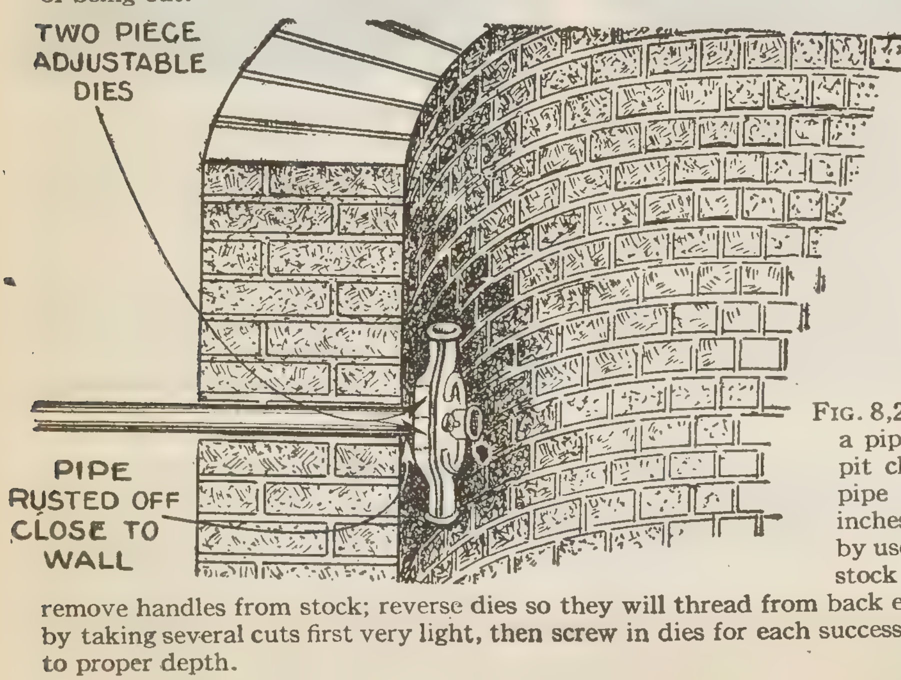
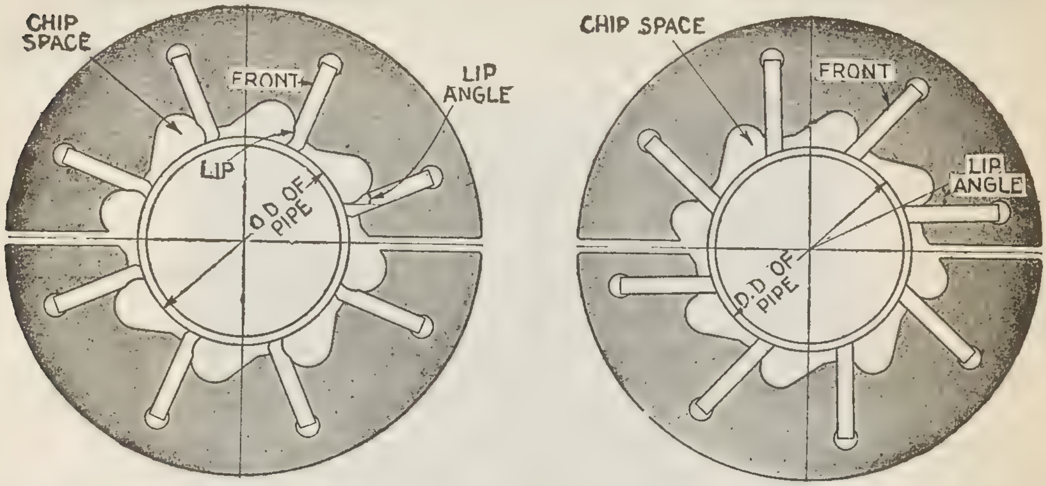


Fig. 8,247. — Re-threading a pipe in circular pump pit close to wall. If the pipe only project two inches it may be threaded by use of Armstrong type stock and die. ***To thread,*** remove handles from stock; reverse dies so they will thread from back end of stock; thread by taking several cuts first very light, then screw in dies for each successive cut till threaded to proper depth.

or cement were used, but with or without cement, a very small amount of perfect thread will produce a tight joint.



FIGS. 8,248 and 8,249.—***Chip space.*** *This is the space required in the die holder* ***in front of*** *the chaser to allow room for the chips to curl off naturally instead of accumulating.* If there be insufficient space, the chips will rapidly pack in front of the chaser and will soon begin to tear the thread. Where no chip space is cut in the die ring, the chaser should project at least ¾ in., otherwise a clogging effect will be experienced. The above figures show best design for chip space; here an easy curve is provided for the chips to follow, while the back of the chaser is well supported.

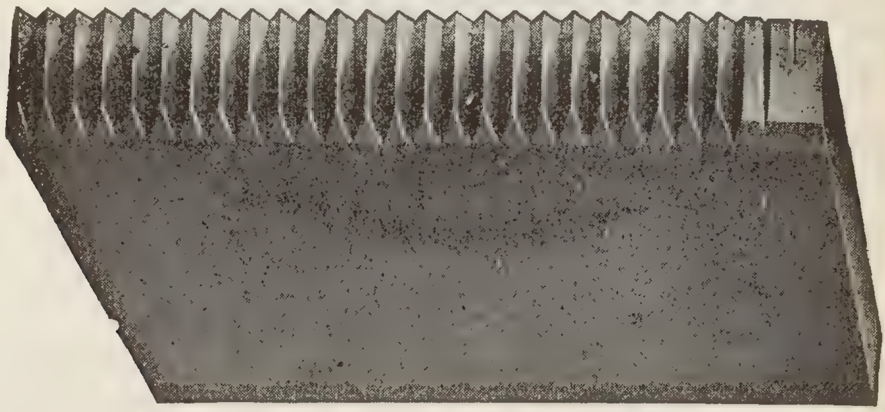
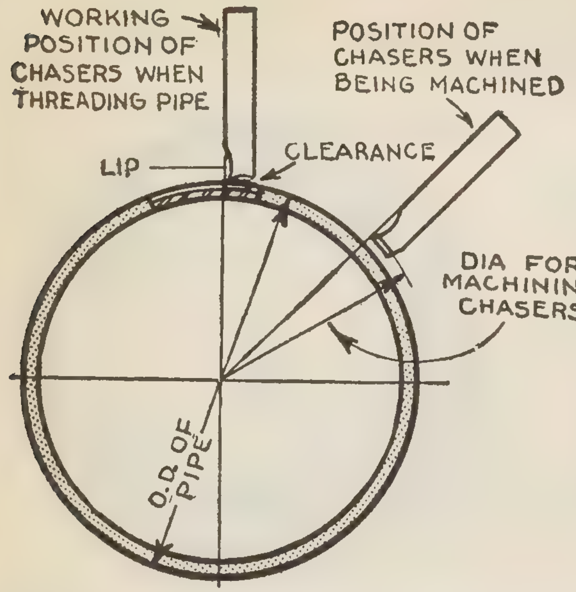
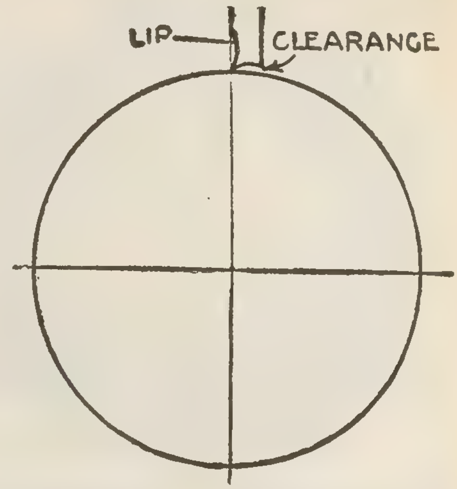
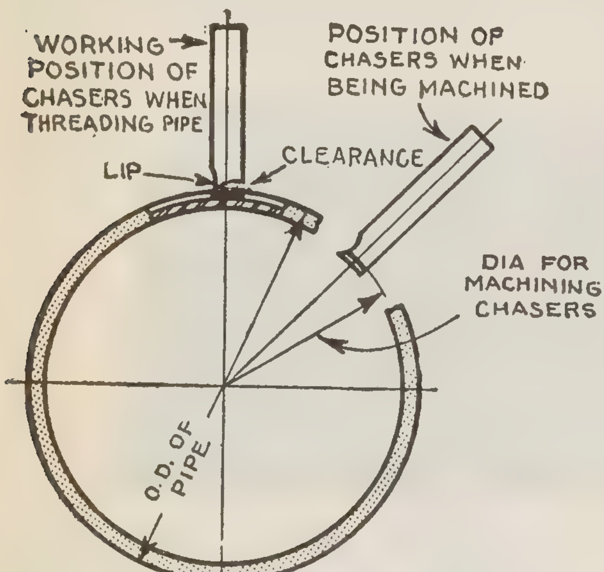


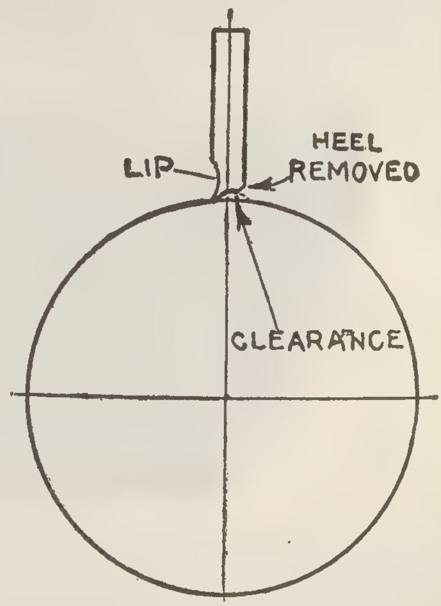
FIG. 8,250.—***Clearance.*** This is *the angle between the threads of the chasers and the threads of the pipe.* It is secured in various ways, depending upon the position in which the chasers are held in the frame. The effect of ideal clearance is shown in the figure which is from a photograph of a chaser after considerable use. When this chaser was set in the holder, the sides of the thread were uniformly dark in color, just as they were left after being hardened and tempered. When the chaser had been in use for some time the sides of the threads became polished, brighter at the cutting edge and gradually shading almost to their original color at the back. The chaser of a die which shows this condition will work freely, cut clear, will not tear the thread and will be durable. When chasers show polish from cutting edge to the back, there is a lack of clearance causing the cutting edge to work hard, heat and make a rough, torn thread.





FIGS. 8,251 and 8,252.—Radial or center cut chaser and method of obtaining clearance. To ***obtain clearance*** the chasers in the machining position are ***set out*** larger in diameter than the size of pipe for which they are intended. Thus for a 6 inch die, the chasers would be machined to about 7/16 in. greater diameter. The effect of this is shown in an exaggerated manner in fig. 8,252, where it can be seen that the thread of the chasers (of larger diameter) gradually recedes from the thread on the pipe.

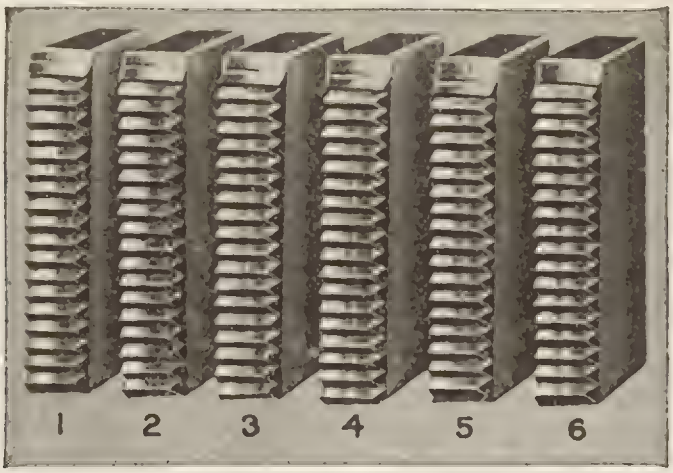


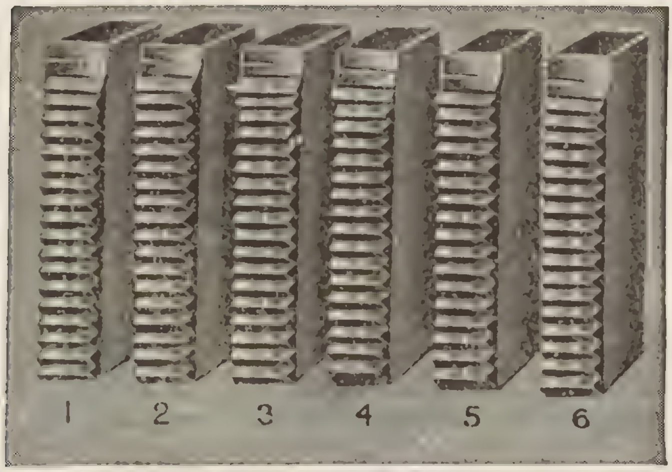


FIGS. 8,253 and 8,254.—Advanced cut or stock on center chaser and method of obtaining clearance. The cutting edge as shown is set *ahead* of the radial line which runs through the center of the chaser. ***To obtain clearance*** the chasers in the machining position are *set in* smaller in diameter than the size of pipe for which they are intended. With this type of die the chasers are *set in* as much as the radial cut chasers are *set* out. This is shown exaggerated in fig. 8,254 where it can be seen how the chaser thread being cut to a smaller radius recedes from the pipe thread. In this type of die the rear half of heel of the chaser should be ground off as shown, otherwise it will drag on the pipe threads and injure them.

Occasionally pipe is rejected on account of small grooves that sometimes occur in threads because the weld is not perfectly brought up.

A groove of this kind could not possibly produce a leak unless it ran the entire length of the thread contact, and in depth went below the bottom of the thread; such defect is, however, rarely encountered.





FIGS. 8,255 and 8,256.—Correct and incorrect grinding of chasers, illustrating ***lead*** or ***throat.*** Lead is the angle which is machined or ground on the front of each chaser to enable the die to start on the pipe, and also to distribute the work of making the first cut over a number of threads. The proper amount of lead is about three threads. As the heaviest cutting is done by the lead, it should have a slightly greater clearance angle than the rest of threads on the chaser. ***In the correctly ground*** set of chasers, fig. 8,255, it will be noticed that the first or lead thread gradually increases in size from a mere scratch on No. 1, to a thread the full width on chaser No. 6. ***In the incorrectly ground set*** of chasers, fig. 8,256, this sequence of lead thread length does not obtain. The effect of this error is to unevenly distribute the work, causing the chasers which do the most work to become dull, thus making it difficult for the die to take hold when starting to cut a thread. It is the improperly ground lead which makes a die let go after being fairly well started, dulling the chaser and spoiling the thread.

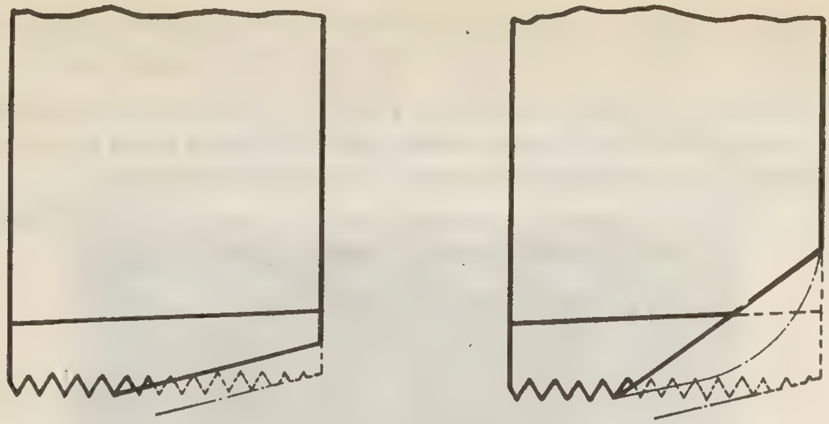


FIG. 8,257 and 8,258.—Correct and incorrect methods of grinding chasers for lead. It should be noted that if the lead in only one chaser require regrinding, the whole set must be gone over to make the dies cut evenly. A broken tooth should always be ground out of a chaser with a thin emery wheel, as the rough portion, if allowed to remain, is likely to tear the thread on the pipe.

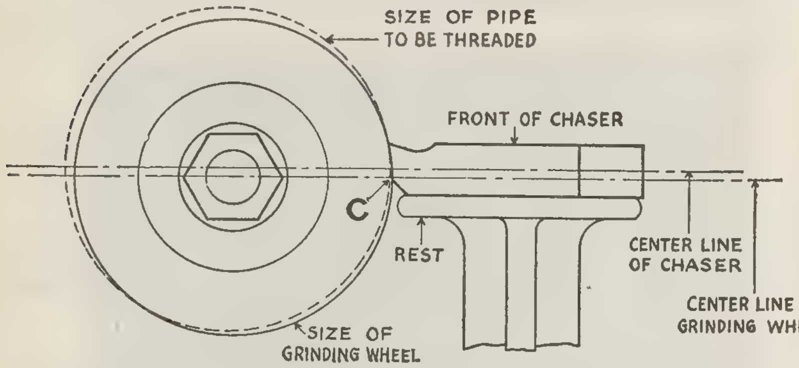


FIG. 8,259.—Proper method of grinding chasers to secure clearance in lead or throat. The chaser is raised or lowered accordingly as the design of the die requires: **C**, indicates the amount of clearance which will be obtained. The figure shows the approximately correct position for grinding a "stock on center" chaser to secure proper clearance on lead. The chaser in this case should be held in a perfectly horizontal position, the back of the chaser being a little below the center of the grinding wheel, which, for purpose of illustration, is shown as about the same diameter as that of the pipe. Greater clearance may be obtained by slightly raising the rest. When a grinding wheel somewhat larger than the pipe diameter is used, the center of the chaser should be slightly above the center of the wheel. The clearance may be *reduced* by lowering the rest, but the chasers should always be held horizontal unless a specially designed jig or fixture be used to hold the chaser at correct grinding angle.

NOTE.—***In backing off*** a solid die, where a common hand stock is used, care should be taken to see that the chaser does not jump the thread channel, causing cross threading or stripping. This is more particularly apt to happen when backing the die off the last few threads, that is, the first threads cut on the pipe.

Making Tight Joints for Very High Pressures.—There are many pipe fitters who do not understand the conditions that are necessary in order to make good screw joints with pipe and fittings, especially when they are intended to withstand very high pressure. The Crane Co. claim that tight joints for 1,000 lbs. air may be made with the ordinary line pipe, providing clean cut threads are made, and extraordinary care and intelligence are exercised in putting them together. The secret of making a tight joint is to avoid or overcome the friction incident to screwing pipe and fittings together.

The importance of avoiding friction and heat is illustrated in one instance where a pipe line was being put together in the field by machinery. The machine would do the work quickly, and the workmen concluded that they had tight joints, when the joints became hot; but after the material was cold, and the heat of the friction was gone, the joints would not be tight. The fact of the matter was that the heat showed conclusively that the threads had not been properly cleaned, and instead of the heat being an evidence of a tight joint, it was evidence of a bad joint.

It must be evident to any one who has given any thought whatever to this subject that in order to make good joints, the iron must be brought together as solidly as possible. To secure this result, the first essential is that the threads should be absolutely clean; and the next is that the very best lubricant should be used in order to prevent friction, and they should not be screwed up fast enough to make any change in the temperature of the material.

It is necessary that the threads be cut clean, that is, that taps and dies be in perfect condition.

A taper thread is not absolutely necessary to the making of a tight joint. (In one experiment The Crane Co. made one joint with coupling which had no taper at all, and the others but very little). Nor is a large amount of bearing necessary to make a tight joint—although for permanency and serviceability the standard length of threads and taper is considered necessary and correct.

It must be evident that the longer the thread the more tendency to friction, which prevents the iron coming up close together, not to mention the natural irregularities in the threads acting in the same direction. It should be understood that absence of heat in pipe or coupling does not mean absence of grit or gum in the threads. Dirty threads may be screwed up very slowly, and thus avoid the heating due to friction, and yet the joint be anything but tight.

Cutting Nipples.—The pipe fitter usually makes any nipples required. but usually better nipples (especially the close and short variety) can be obtained from the supply house at less cost.

No pipe fitter deserving to be called such will attempt to cut nipples without a proper nipple holder, although some plumbers and others are often guilty of such practice when working by the day instead of by the job.

The ordinary method of cutting nipples as indulged in by some plumbers and others, for lack of proper tools, is very unsatisfactory.

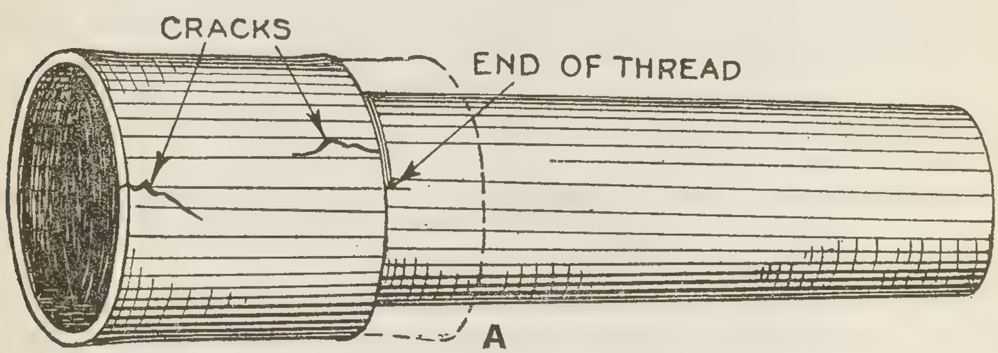


FIG. 8,260.—Makeshift nipple holder as used by some steam fitters. ***It consists of*** a short length of pipe having a coupling on one end. ***In operation,*** one end of the nipple is screwed into the coupling, and the die applied to the other end. In doing this the turning force necessary to cut the thread being considerable, the coupling will be forced on the pipe (beyond the thread) to some position indicated by the dotted line **A**, straining the coupling beyond its elastic limit and probably cracking same as indicated. The nipple thus made is removed from the coupling and die by the aid of a Stillson wrench and some profanity. The coupling now being in a condition known to a certain class of workmen as "*on the hog*," it is replaced by a new one each time a nipple is to be cut. ***In sending in the bill,*** the waste of time and couplings are of no consequence to an unscrupulous mechanic, for these items are charged to the customer along with such things as candles, waste, charcoal, oil, matches, etc.—***at a very HANDSOME profit.***

This consists of using a short piece of pipe with a coupling on the end as a home made nipple holder. This is placed in the pipe vise and a piece of pipe threaded on one end screwed tightly with the coupling, and after cutting off to length desired for the nipple, an attempt is made to thread the other end. Owing to the considerable effort required to cut the thread the nipple turns in the coupling until the latter is strained to the splitting point and in fact usually does split before many nipples have been cut in this way, *resulting in profanity and a waste of time.*

In emergency, the proper way to cut a nipple with such makeshift holder so as not to split the coupling is to use adjustable dies, as, for instance, the Armstrong pattern (figs. 8,221 to 8,223). First take a very light cut, then adjust dies and take one or more additional cuts to finish. The cost of a properly made nipple holder, such as shown on page 8,261, is so small that it should be included in every pipe threading outfit.

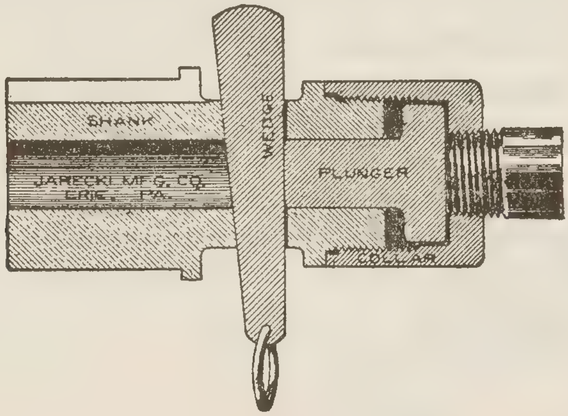


FIG. 8,261.—Jarecki nipple holder for threading close and short nipples.

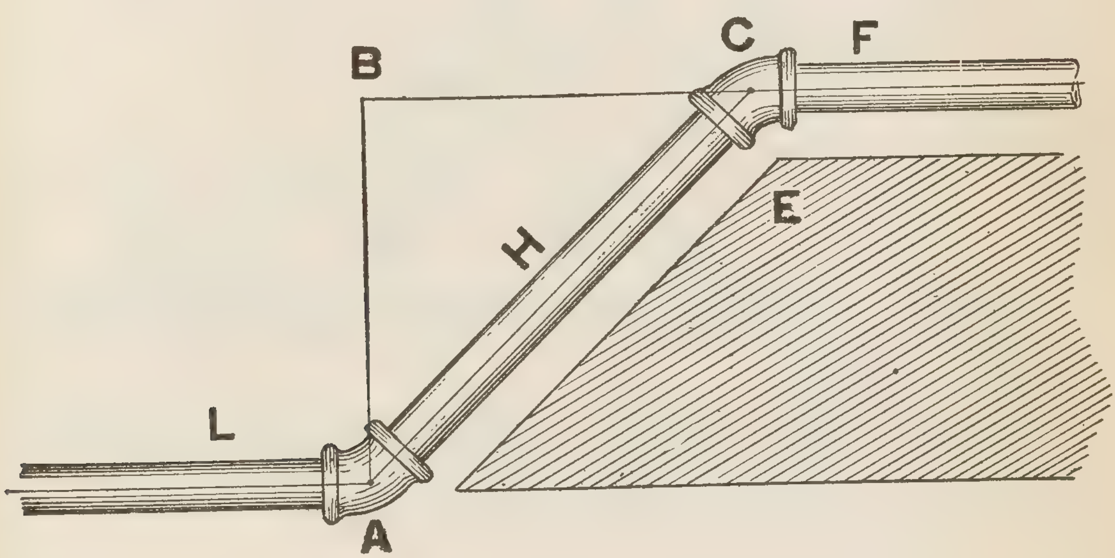


FIG. 8,262.—Pipe line connected with 45° elbows illustrating offsets and method of finding length of connecting pipe H.

Calculation of Offsets.—In pipe fitting the term *offset* may be defined as *a change of direction (other than 90°) in a pipe*

bringing one part out of, but parallel with the line of another. Thus in fig. 8,262, it is necessary to change the position of pipe line L, at A, to same parallel position as that of line F, because of some obstruction such as the wall E of the building. When the two lines L and F are to be piped with elbows other than 90° elbows, the pipe fitter encounters a problem of finding the length of the pipe H, connecting the two elbows A and C, also to determine the distance BC, in order to fix the point A, so that the two elbows A and C will be in alignment.

Of course in the triangle ABC, the length of pipe AC, and either offset (AB or BC that may be required) are quickly calculated by solving the triangle ABC, for the desired member, but this involves taking the square root which is not understood by every mechanic, hence an easier method will be given for those having limited knowledge of mathematics.

1st Method.

In the triangle ABC

$$\overline{AC}^2 = \overline{AB}^2 + \overline{BC}^2$$

from which

$$AC = \sqrt{\overline{AB}^2 + \overline{BC}^2}$$

Example.—If in fig. 8,262, the distance between pipe lines L and F be 20 ins. (offset AB) what length of pipe H, is required to connect with the 45° elbows A and C.

When 45° elbows are used both offsets are equal, hence substituting in equation (1).

$$AC = \sqrt{20^2 + 20^2} = \sqrt{800} = 28.28 \text{ ins.}$$

It should be carefully noted that the value for the length of the pipe as just obtained does not allow for the projections of the elbows and this must be taken into account. This is shown in fig. 8,263.

2nd Method

The following rule will be found convenient for calculating 45° elbows.

Rule.—*For each inch of offset add $\frac{58}{128}$ of an inch and the result will be the length between centers of the elbows.**

Example.—Calculate length AC (center of elbows) of the preceding example by the above rule.

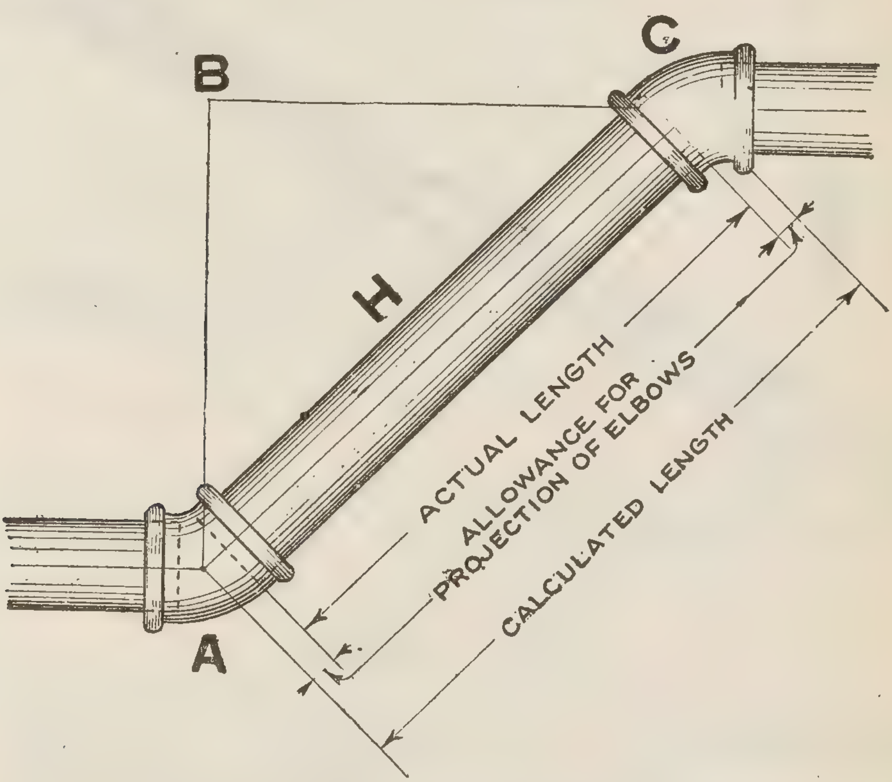


FIG. 8,263.—Calculated and actual length of connecting pipe with elbows other than 90°. Note carefully the allowances or deduction from calculated length for projections of elbows.

$$20\times\frac{53}{128}=\frac{1060}{128}=8^{9}/_{32}$$

adding this to the offset

$$20+8\tfrac{9}{32}=28\tfrac{9}{32}$$

This is the calculated length, and to obtain the actual length, deduct the allowance for projection of the elbows as shown in fig. 8,263.

3rd Method

There are elbows of angles other than 45°, such as 22½, 11¼, etc., which the piper fitter often encounters. For such, the distance between elbow centers can easily be found by use of the following table of constants.

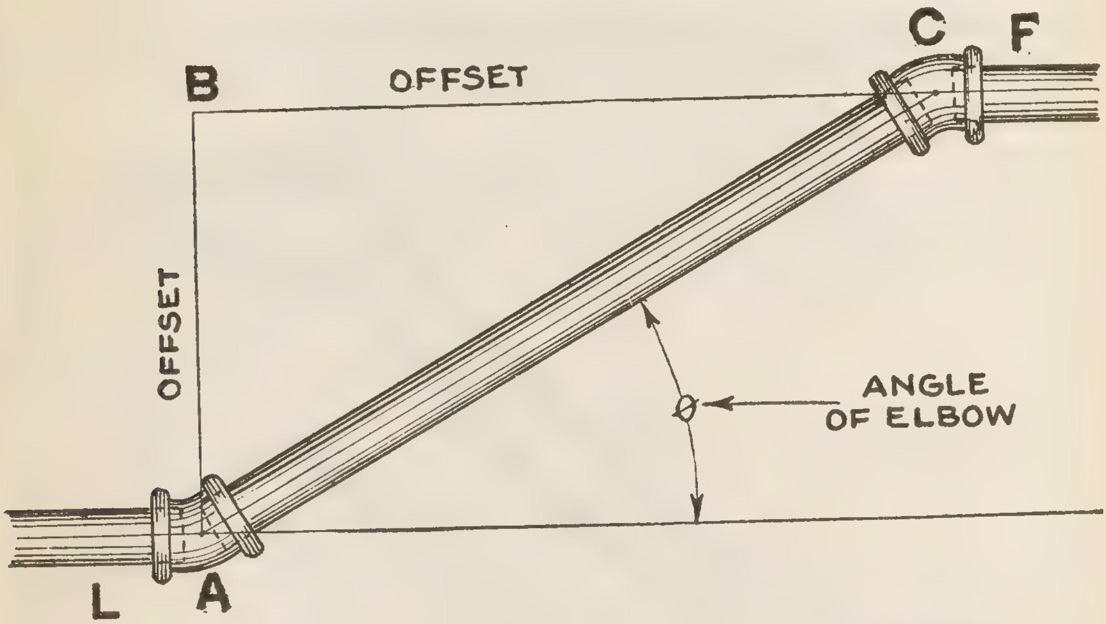


FIG. 8,264.—Diagram for elbow constant.

Elbow Constants

Angle of Elbow	Elbow Centers AC	Offset AB
60°	1.15	.58
45°	1.41	1.00
30°	2.00	1.73
22½°	2.61	2.41
11¼°	5.12	5.02
5⅜°	10.20	10.15

NOTE.—In the above table the letters refer to fig. 8,264.

In using the table on the preceding page, use is made of the rule which follows:

Rule.—*To find length between centers of elbows multiply offset by constant for the elbow used.*

That is, referring to fig. 8,264.

$$AC = \text{offset } AB \times \text{constant for } AC\ldots\ldots(1)$$
$$BC = \text{offset } AB \times \text{constant for } AB\ldots\ldots(2)$$

Example.—If in fig. 8,264, the distance between pipe lines L and F, (offset AB) be 20 ins., what is length of offset BC, and distance AC, between center of elbows, for 22½° elbows.

In the table constant for AB, with 12½° elbow is 241. Substituting values in equation (2).

$$BC = 20 \times 2.41 = 48.2 \text{ ins}$$

For distance AC, between centers of elbows, find in table constant for AC=2.61. Substituting in equation (1).

$$AC = 20 \times 2.61 = 52.2 \text{ ins.}$$

4th Method.—Offsets may be calculated by aid of trigonometry, as explained in Guide No. 1, pages **1,128** and **1,129**. The following examples will illustrate the use of the tangent.

Example.—In fig. 5,876, page **1,128**, what is the length of offset OB?

From table on page **1,129**, tan 60° = 1.7321.

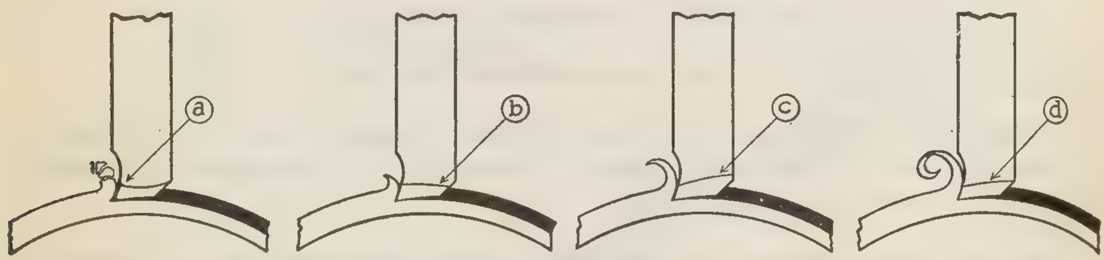
Length offset OB = 1.7321 × 8 = 13.86 ins.

Example.—In fig. 5,876, page **1,128**, what is the length of the offset AB?

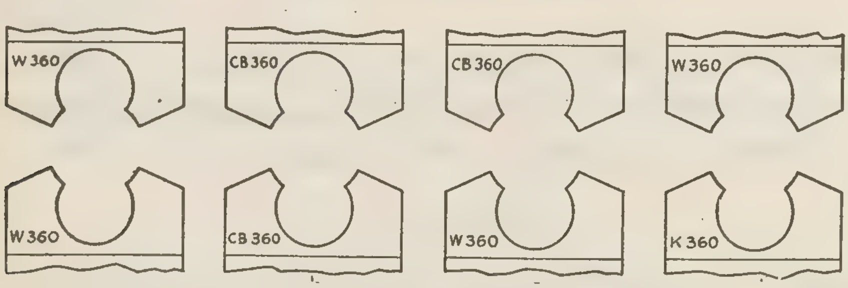
From table on page **1,129**, tan 30° = .5774 long OB (from preceding example) = 13.86 ins.

Length offset AB = .5774 × 13.86 = 8 ins.

Pipe Tapping.—Frequently in pipe fitting, it is necessary to cut internal threads on pipes, as in making pipe headers, lubricator connections, etc. This is called *tapping*, and involves 1, drilling holes to correct diameter, 2, sometimes reaming, and 3, cutting the internal threads by means of a *tap*. It is first necessary to know what size hole is required for the size of tap.

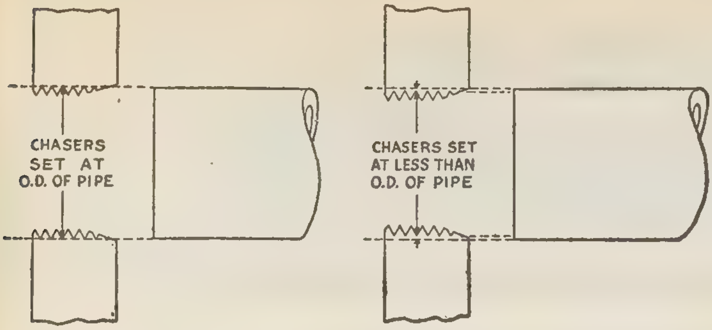


FIGS. 8,265 to 8,268.—Results obtained in grinding chasers. Fig. 8,265, ***cutting edge rounded off.*** No clearance in lead. Result of careless grinding and lack of temper in steel of chaser, fig. 8,266, ***no clearance in throat or lead,*** caused by grinding the lead at too low a point on the wheel; fig. 8,267, ***too much clearance in thread or lead,*** caused by grinding at too high a position in relation to center of grinding wheel. This causes the die to chatter with resulting rough wavering thread, if not in fact stripping short pieces from the thread or breaking the chaser; fig. 8,268, ***correct throat or lead.***

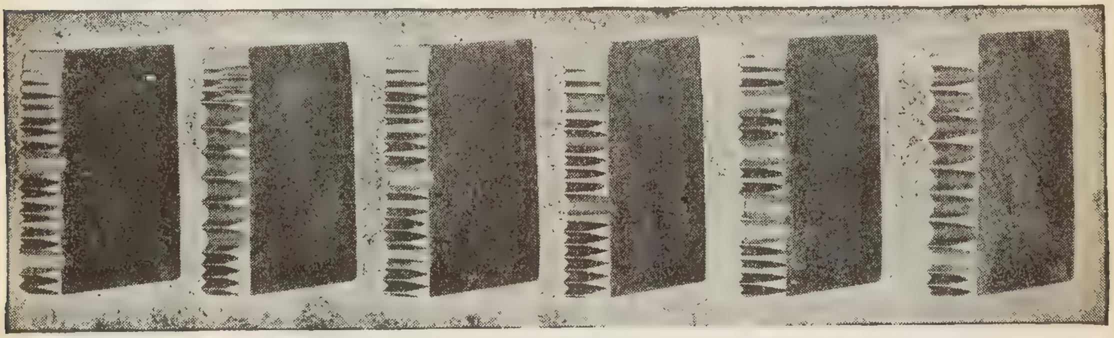


FIGS. 8,269 to 8,272.—Proper and improper selection of chasers. Figs. 8,269 and 8,270 show two sets of chasers properly arranged in pairs according to serial number and letter; figs. 8,271 and 8,272, improper arrangement of chasers, the serial numbers of which show that the chasers belong to three different sets of dies: CB360, W360, and K360. By using chasers from two or more sets, the lead threads may not follow in proper order, resulting in unsatisfactory threads. In many cases it has been found that only the *number* of a chaser has been noted and not the *serial letters*, resulting in the pipe being condemned as hard to cut and the die as being defective. In placing adjustable chasers in holder, *care should be token to set them at **equal distances** from the centev, **to avoid** impevfect threads.*

The following table gives drill sizes which permit of direct tapping without reaming the hole beforehand.



FIGS. 8,273 and 8,274.—Correct and incorrect setting of chasers with respect to depth of cut. Pipe fitters are quite apt to be satisfied that the chasers are properly set so long as the lead is sufficient tc allow easy starting of the die, but it frequently happens that the chaser *is set too deep* and the die is literally forced on the pipe after passing the first two or three threads, resulting in stripping the top off the threads (sometimes the whole thread), ***over-heating and ruining the die.***



FIGS. 8,275 to 8,280.—Effect of excessive grinding. The teeth in these chasers were gound out to illustrate that even excessive grinding at times, if properly done, does not render a chaser useless. These chasers sill cut good threads, though the use of chasers in this condition is not recommended. It will be noted that there are no broken, ragged teeth to pick up stickers and tear the top off the threads. The figures also show very clearly the grinding of the heel, a precaution necessary to prevent tearing of the threads, when backing off a die that cannot be opened before removing from the pipe. Old chasers with dull and rusted threads may be resharpened with emery and oil. If too dull, they may be rehobbed. Receding dies may be rehobbed and lead reground to cut next larger size of pipe.

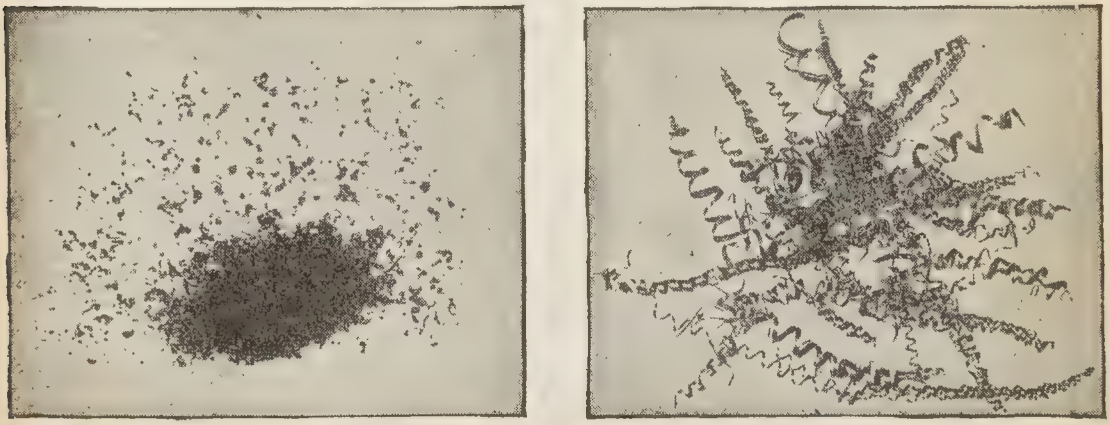


FIG. 8,281.—Appearance of chips thrown off by a chaser of incorrect shape.
FIG. 8,282.—Appearance of chips thrown off by a properly designed chaser.

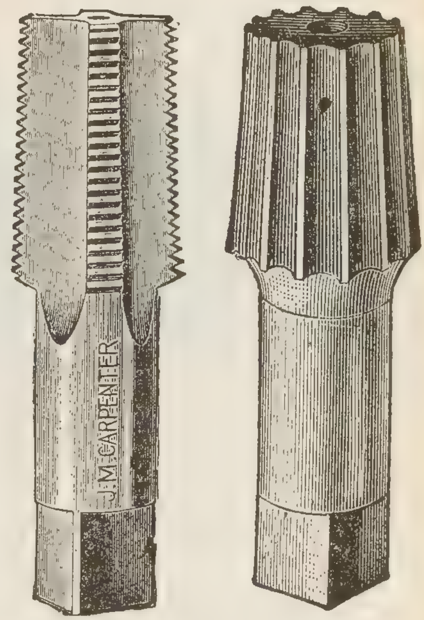
Drill Sizes for Briggs Standard Pipe Taps

(For direct tapping without reaming)

Size of pipe	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4
Size of drill	21/64	7/16	9/16	45/64	29/32	1 9/64	1 31/64	1 47/64	2 13/64	2 5/8	3 1/4	3 47/64	4 15/64

Drill Sizes for Pipe Taps

Size Tap Inches	BRIGGS STANDARD		BRITISH (Whitworth) STANDARD	
	Thread	Drill	Thread	Drill
1/8	27	21/64	28	5/16
1/4	18	27/64	19	7/16
3/8	18	9/16	19	9/16
1/2	14	11/16	14	23/32
5/8	...	....	14	25/32
3/4	14	29/32	14	29/32
7/8	....	....	14	1 1/16
1	11 1/2	1 1/8	11	1 5/32
1 1/4	11 1/2	1 15/32	11	1 1/2
1 1/2	11 1/2	1 23/32	11	1 23/32
1 3/4	....	....	11	1 31/32
2	11 1/2	2 3/16	11	2 3/16
2 1/4	....	....	11	2 13/32
2 1/2	8	2 9/16	11	2 25/32
2 3/4	....	....	11	3 1/32
3	8	3 3/16	11	3 9/32
3 1/4	....	....	11	3 1/2
3 1/2	8	3 11/16	11	3 3/4
3 3/4	....	....	11	4
4	8	4 3/16	11	4 1/4
4 1/2	8	4 11/16	11	4 3/4
5	8	5 1/4	11	5 1/4
5 1/2	....	....	11	5 3/4
6	8	6 5/16	11	6 1/4
7	8	7 5/16	11	7 5/16
8	8	8 5/16	11	8 5/16
9	8	9 5/16	11	9 5/16
10	8	10 7/16	11	10 5/16



FIGS. 8,283 and 8,284.—Pipe tap and pipe reamer.

The table at the left (by Greenfield), gives drill sizes for pipe taps for both the Briggs or American Standard, and Whitworth, or British Standard.

Figs. 8,283 and 8,284 show a pipe tap and reamer; fig. 8,285 combined tap and drill reamer. Since the thread is

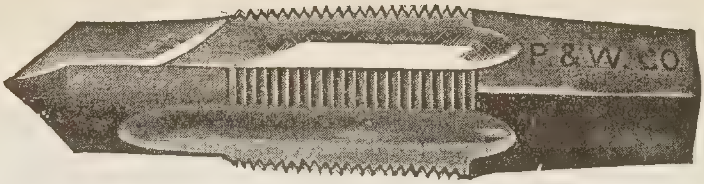
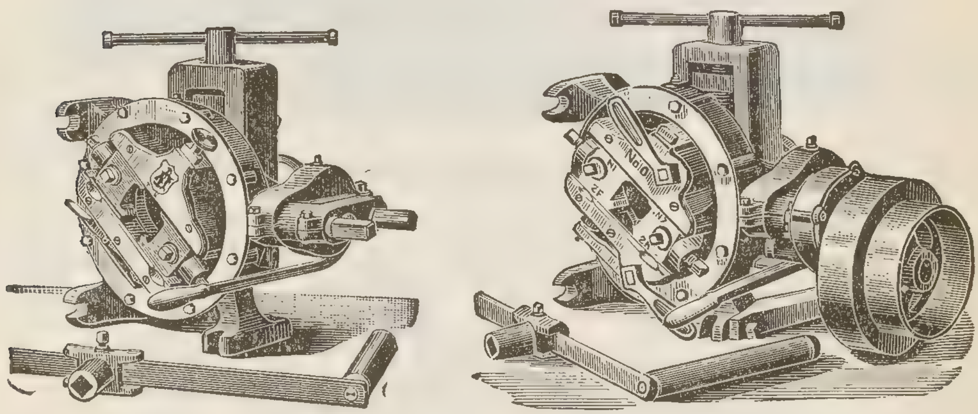


FIG. 8,285.—Pratt and Whitney combined pipe tap and drill.



FIGS. 8,286 and 8,287.—Armstrong pipe threading machine showing hand and power drive. Capacity pipe ½ to 2 inches; bolts ½ to 1½ inches. The dies are adjustable and are opened after cutting thread, and, after removing pipe, return to size without resetting. Two speeds are provided for hand power; the operator can cut small pipe from ¼ to 1 inch rapidly, and by changing handle to other spindle, cut 1¼ to 2 inches, not so quickly, but easily.

NOTE.—It is highly important that threading dies be kept in good working condition, for even with uniform pipe it is difficult to secure good threads if the chasers of a die be lacking in proper lip angle, clearance in lead or thread, have broken teeth, or if the die be lacking in chip space, sufficient number of chasers, etc.

NOTE.—For cutting threads on regular Bessemer steel pipe, each chaser should have a lip angle of 15 to 20 degrees for open hearth, at least 25 degrees. By grinding a slightly curved lip of this angle, an easy cutting action is given to the chaser, similar to that of a properly ground lathe tool, and the effect of pushing the metal off instead of cutting it is avoided. If there be a square corner or shoulder at the top of the lip, this should be removed, as it forms a place where chips may lodge and pile up, resulting in torn threads and unnecessary friction and often in condemnation of the thread by the inspector in charge. Clearance is the space between the pipe threads and the teeth of the chaser.

tapered, it might be inferred that after drilling, the hole should be reamed with a tapered pipe reamer, but this is not necessary if the size of the drill be increased slightly.

In drilling a pipe for tapping, care should be taken that the drill be guided in a radial direction and perpendicular to the pipe axis. Fig. 8,289 shows a pipe drilling crow designed for

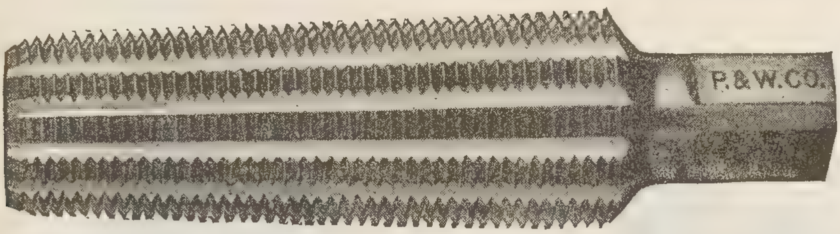
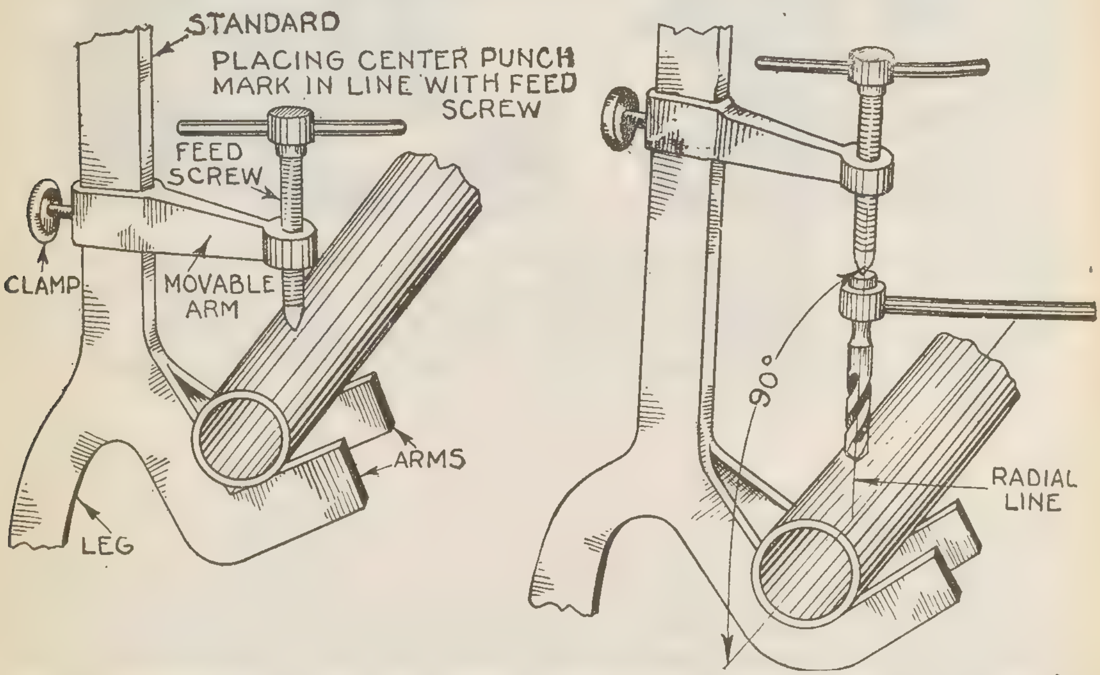


Fig. 8,288.—Pratt and Whitney pipe hob or master tap for cutting the threads of dies.



Figs. 8,289 and 8,290.—Pipe drilling crow and method of using. The crow consists of two V arms and a leg forming a tripod support for the upright rectangular post or standard. An arm is arranged to slide on the standard and is secured in any position by the clamp. At the end of the arm is tapped a feed screw with hardened point, which is directly over the line joining the apex of the V arms, hence the point of the feed screw, when lowered, will touch the surface of a pipe resting in the V arms at a point so located that the axis of the feed screw passes through the center of the pipe. Moreover, the feed screw being perpendicular to the line joining the apices of the V arms, if a drill be applied at the same point touched by the feed screw, and guided by the feed screw as in fig. 8,290, the hole will be drilled radially and at right angles to the pipe axis.

the purpose and fig. 8,290, pipe and drill in position. Of course where such device is not at hand, various makeshifts have to be resorted to.

Fig. 8,291 shows a method of holding a ratchet drill in place, the drill being aligned by square and eye. In tapping, special care should be taken not to turn the tap with too much force, especially with small taps, to avoid danger of breaking. If the tap do not turn reasonably easy, work it back and forth and

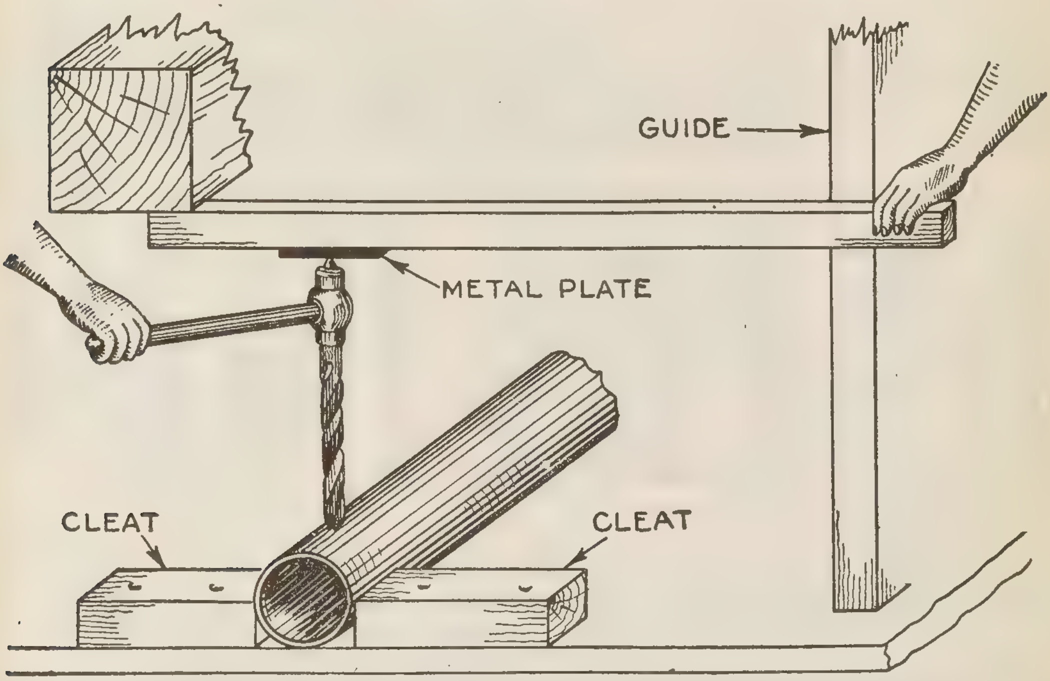


FIG. 8,291.—Ordinary method of drilling a pipe for tapping where a crow is not available. One end of a lever is placed under the edge of a timber, as shown, while a helper bears down on the other end, sliding the lever in contact with a vertical timber, using it as a guide. When this plan is adopted it is not necessary to operate the feed screw in the upper part of ratchet, as the lever follows it down. This could not be done in the case of a deep hole, as the top of drill would be carried out of place, but it is all right for drilling one or more holes in a pipe as shown.

occasionally back off to remove chips, and always use plenty of oil or lard in tapping wrought pipe.

Pipe Bending.—There are numerous instances where it is desirable to bend the pipe rather than use additional fittings

to make directional changes in the pipe line. With the proper facilities pipe may be bent within certain limits without difficulty.

The following table gives the advisable and minimum radii to which standard wrought pipe may be bent.

Radii for Standard Wrought Steel Pipe Bends

(As recommended by National Tube Co.)

Pipe size inches	Center to face	Minimum radius inches	Pipe size inches	Advisable radius inches	Minimum radius inches	Pipe size inches	Advisable radius inches	Minimum radius inches
1/8	2	1¼	4	24	16	12	72	48
¼	2¼	1⅜	4½	27	18	13	84	60
⅜	2½	1½	5	30	20	14	90	68
½	3¼	1¾	6	36	24	15	100	76
¾	4	2¼	7	42	28	18 O.D.	125	90
1	4½	2½	8	48	32	20 O.D.	150	120
1¼	5	3	9	54	36	22 O.D.	165	132
1½	5¾	3¼	10	60	40	24 O.D.	180	144
2	7	4½	11	66	44	......	......	......
	Advisable radius							
2½	15	10	......	......	......	......	......	......
3	18	12	......	......	......	......	......	......
3½	21	14	......	......	......	......	......	......

The radii given in the table are as short as should be used to secure good results and if they be reduced, the thickness of the pipe must be increased. As the radius is decreased, however, it becomes more difficult to avoid buckles.

For making bends The National Tube Co. offer the following suggestions: Bends 12 ins. and smaller to regular dimensions to be made of full weight pipe. Bends 14, 15 and 16 ins. outside diameter to be not less than ⅜ in. thick.

Bends 18 ins. outside diameter and larger to be not less than 7/16 ins. to ½ ins. thick.

For offset bends try to make a straight length between the bends in preference to the direct reverse bend.

With the welded flanges there must be a short, straight length of pipe between the bend and the flange. On sizes under 4 ins. this should equal, at least, 1½ diameters; on sizes over 4 ins. it should equal at least 1 diameter of the pipe. In all cases it is better if equal to 2 diameters of straight pipe.

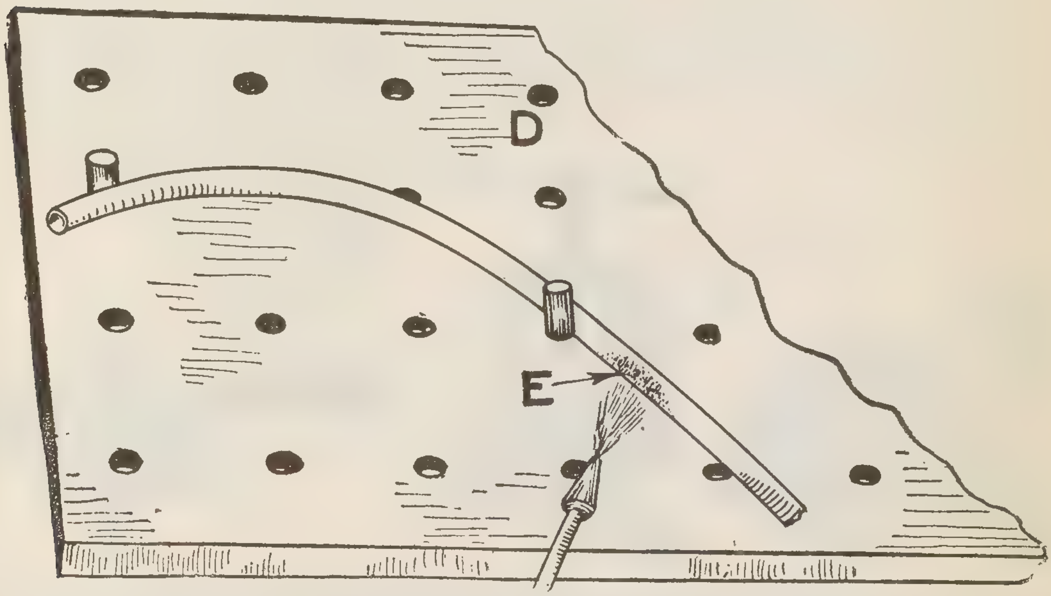


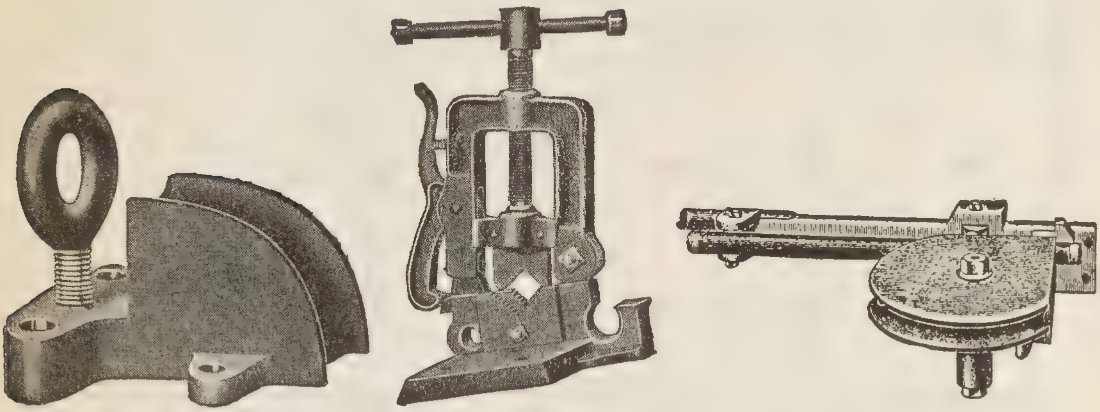
FIG. 8.292.—Bending block and pins. This is a simple method, but requires a careful workman to get a smooth job, and though adaptable to the largest sizes of pipe, may require a tedious amount of work. Two pins are required for the necessary leverage to pull the pipe around. The plate is desirable for keeping the bend in a true plane. ***In bending***, the pipe is heated in a small spot at a time on the inside of the bend, as shown in the shaded portion at E. If the heat extend around the outside of the pipe, this should be chilled with water immediately before bending, the object being to keep the outside cold to prevent flattening the pipe while the pressure of the bending causes the inside to upset and so furnishes the shorter radius for the inside. Only a very small portion of the pipe can be heated at a time and should the pressure cause the inside to start to kink at any point, that place must be immediately chilled with water, and the bending continued further along. On account of the constant shifting of the heat on a very small portion at a time, the use of an oil torch for heating is a great advantage, as it saves carrying the pipe to and from a forge, but the latter can be used if necessary.

Ques. How may pipes be bent by hand without the use of special tools?

Ans. *Completely* fill the pipe with dry sand and cap the ends

so the filling will be retained. Heat the part to be bent; clamp the pipe in a vise as close to the part to be bent as possible. Now cool the *outside* of the curve with water so that the inside, being hot and plastic, is compressed as the bend is made.

The heating should be restricted to the section to be bent. It is usually necessary to heat several times in making a bend to short radius; nothing is gained by overheating. The outside of the bend is cooled with water to force the compression of the metal on the inside, which slightly reduces the volume filled by the sand and this causes the latter to give better support to the walls.



FIGS. 8,293 to 8,295.—Pipe bending devices. Fig. 8,293, Vanderman bending form; fig. 8,294, Vanderman pipe vise with bending form combined; fig. 8,295, small pipe bending machine, suitable for ¾ to 1¼ in. pipe.

For bends over 15 times the pipe diameter the use of water for cooling the outside of the curve is not necessary.

Ques. When the required curve has been obtained how is it retained while bending the other sections?

Ans. By cooling with water.

Pipe Bending Tools.—There are a variety of devices composing hand tools and machines for bending pipe. Fig. 8,293 shows the smallest and simplest device which is intended to be

bolted to a table and is suitable for bending pipe of small sizes ranging from 1/8 to 2 ins. Fig. 8,294 shows a pipe vise with bending forms combined, and fig. 8,295 a machine suitable for pipes 3/4 to 1 1/4 ins. Figs. 8,296 and 8,297 show some interesting tools and pipe bending methods.

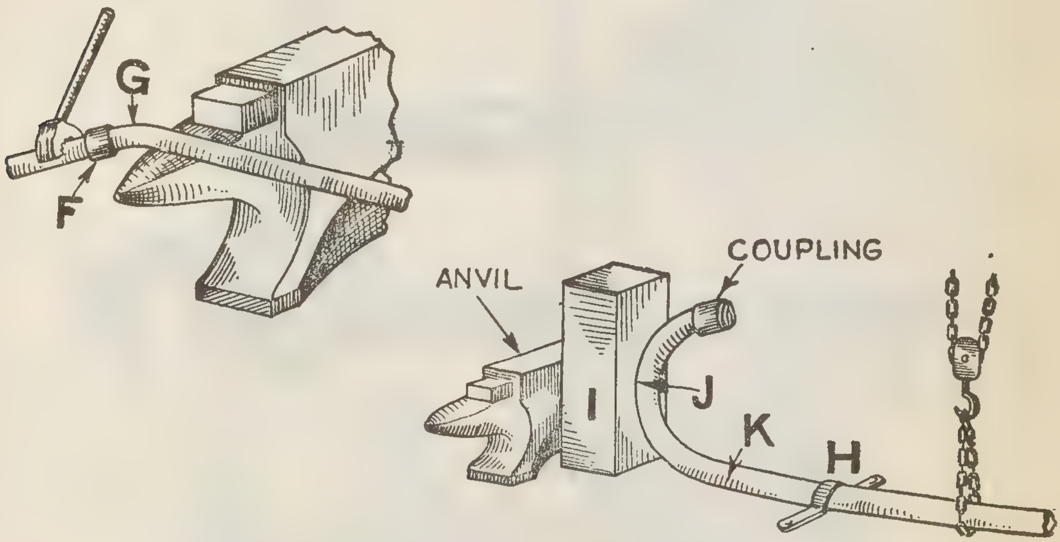
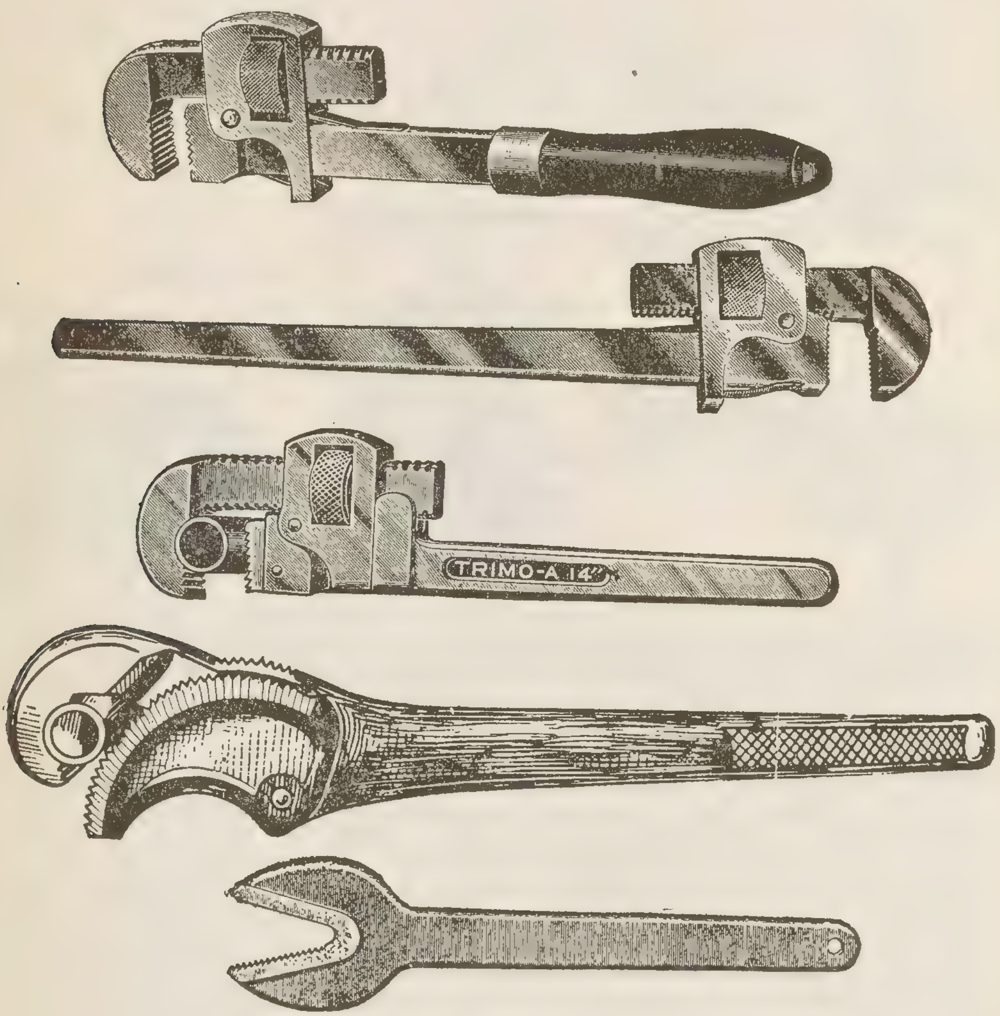


FIG. 8,296 and 8,297.—Anvil method of pipe bending. In fig. 8,296 a coupling and short length of pipe are temporarily fitted on the end of the pipe, as shown at F. A short heat is taken close to the coupling at G, the pipe laid over the horn of an anvil, and with a swage and sledge the bend is started, turning the pipe over on its side if necessary to work out any kinks or flattening that may occur while this first bend is being made. The added section of pipe is then removed and a quite different method continues the work, as shown in fig. 8,297. The clamped band handle H, is now bolted on some distance back from the end, and the pipe itself is suspended by a block and sling, so that it may be easily raised and lowered as necessary, and must be hung from a support far enough above it so that it may be swung pendulum fashion through a swing of three or four feet. A heavy wood block I, for a "butting post" is leaned up against a convenient anvil or wall, as shown. A short heat is then taken on the pipe just beyond and adjoining the portion that was first bent. It is then swung like a ram against the block, and the force of the blow acting on the tangent of the first bend causes a continuation of the bending in this next section, while sufficient upsetting of the material takes place at the same time so that there is no flattening down of the outside, and the pipe holds up to its full form. This same procedure is continued for one section following another, and the pipe rolls up into forms as shown at J, where in this case the shaded portion K, indicates the place where the bending is taking place. Care must be used that the bend does not run out of a true plane, and if there be any tendency toward doing so, the work must be laid on a face plate or anvil and trued up. In working with this method and that of fig. 8,296, the smith must work up to an inside template which has been made up for the radius of the inside of the bend, using care to keep each added bend close to the template size to save any unnecessary bending or straightening of the work later on when it might not be so easily performed without reworking the whole piece.

Assembling.—On large jobs the pipe is usually cut according to a sketch or working drawing and partly assembled at the shop. If no mistakes have been made in following the dimensions on the drawing, and the latter be correct, the pipe and fittings may be installed without difficulty, that is, the last

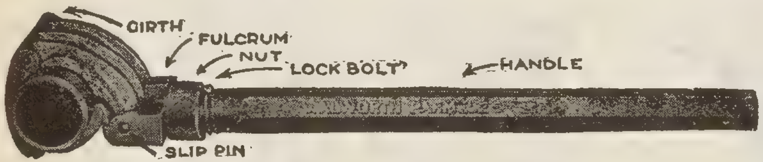


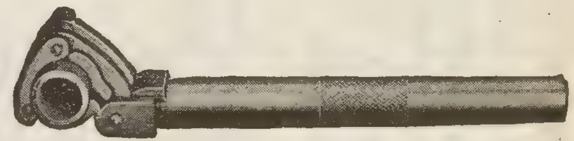
FIGS. 8,298 to 8,302.—Various pipe wrenches. Fig. 8,298, Stillson with wood handle 6 to 18 ins.; fig. 8,299, Stillson with steel handle 18 ins. and larger; fig. 8,300, Trimo; fig. 8,301, Reed; fig. 8,302, Alligator.

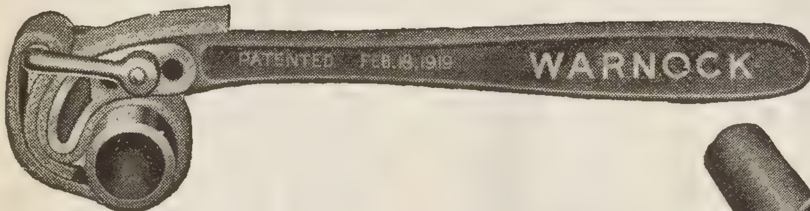
joint will come together or "*make up*." This last joint is either a union, a right and left, or long screw joint, and if errors have

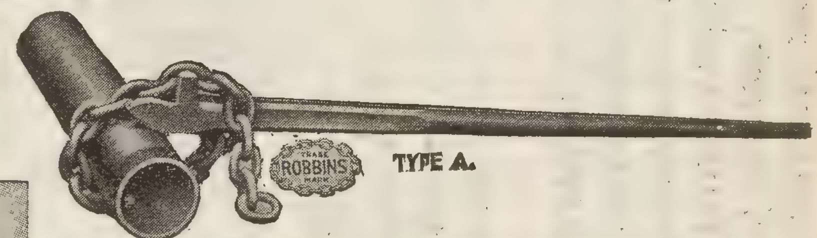
been made in cutting the pipe, it will be difficult or impossible to make up this closing joint.

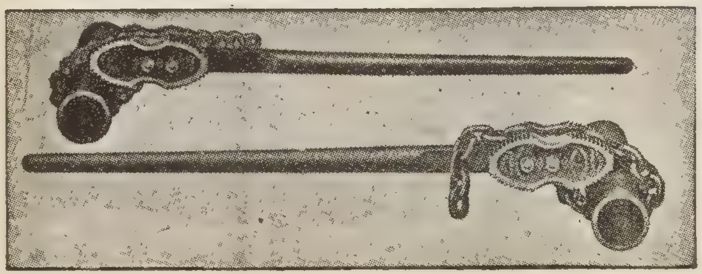
On small jobs no sketch is necessary, the fitter proportioning the pipe lengths mostly

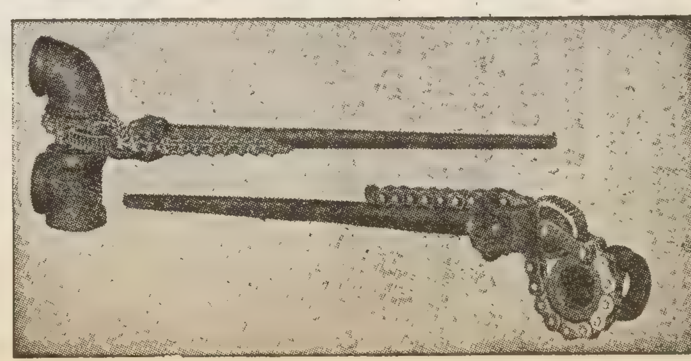








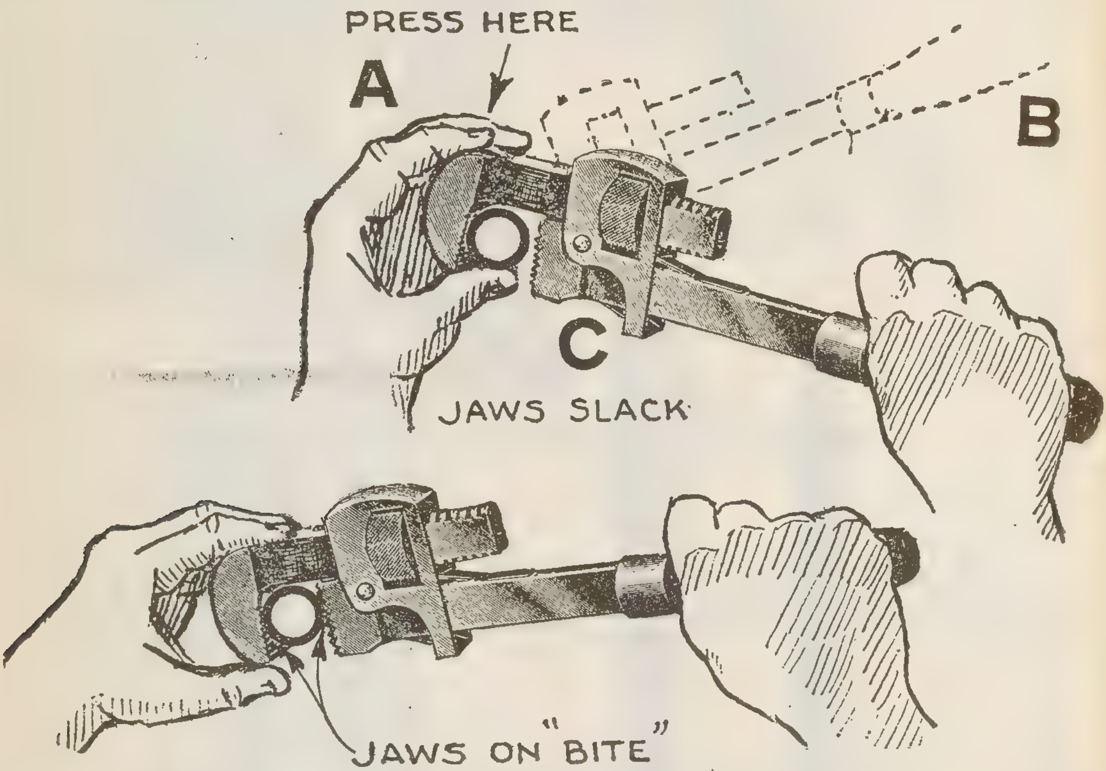




Figs. 8,303 to 8,410.—Various pipe wrenches. Fig. 8,303, Parmelee, nut lock type; fig. 8,304, Parmelee, sleeve lock type; fig. 8,305, Warnock wrench for brass or finished pipe. ***Chain wrenches***: Fig. 8,306, Robbins; fig. 8,307, Vulcan bi-jaw, with flat chain; fig. 8,308, Vulcan bi-jaw with cable chain; figs. 8,309 and 8,310, Agrippa.

"by eye," taking occasional measurements where necessary during the progress of the work. It should be noted that with the great variety of fittings available any pipe system may be arranged in numerous ways and the proper selection of these fittings and general arrangement of the system so that it will be direct, simple, accessible for repairs, etc., is an index of the fitter's ability.

In making up screwed joints, red or white lead, graphite, or some standard joint cement should be used. Of these, red lead



FIGS. 8,311 and 8,312.—How to use a pipe wrench. Adjust wrench so that jaws will take hold of pipe at about the middle part of the jaws. To support wrench and prevent unnecessary lost motion when wrench engages pipe, hold jaw at A, with the left hand pressing it against the pipe. At the beginning of the turning stroke B, with jaw held firmly against pipe with left hand, the wrench will at once "bite" or take hold of pipe with only the lost motion necessary to bring jaw C, in contact with the pipe.

is most extensively used. It is no doubt most efficient in making a tight joint, but it is more difficult to unscrew the fitting in case of repairs than when graphite is used.

In applying the red lead or other material *it should be put on the male thread only;* if put on the female thread, when the pipe is screwed in, some of the red lead will lodge inside the pipe and form an obstruction, especially in small pipes. A convenient method of applying red lead or cement is with an old tooth brush, as in fig. 8,313. In making up a joint it should not be screwed fast enough to produce undue heat, because the resulting expansion of the pipe will not allow a proper number of turns to be made and on cooling and contracting the joint may be loose enough to cause a leak.

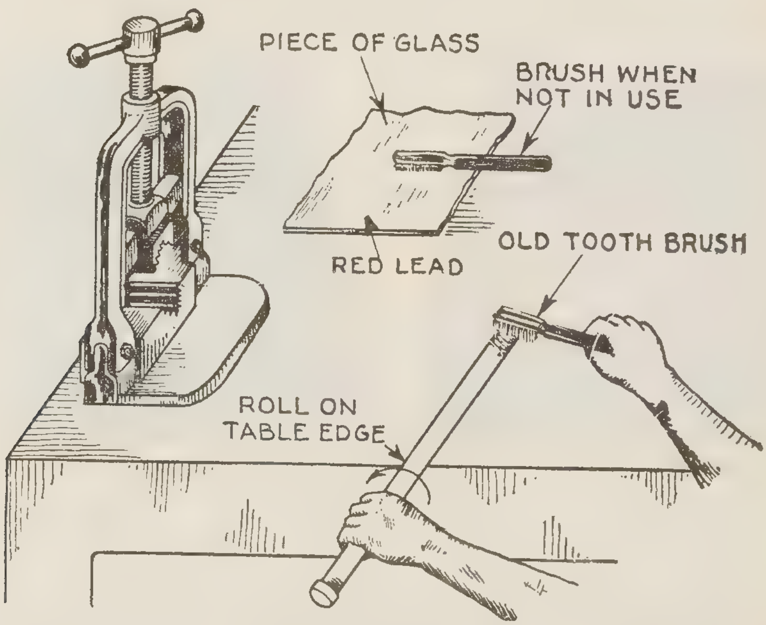


FIG. 8,313.—Method of applying red lead or other material to male thread with an old tooth brush. The pipe is rested against the bench or other support and turned by the left hand in the direction indicated by the arrow while the joint material is applied with the brush as shown. It is unnecessary to put much material on the threads, as it will be simply pushed out and wasted when the joint is screwed up. It should, however, be put on evenly and cover all the threads, care being taken not to let any touch the reamed end of the pipe where it may get inside. The red lead is preferably obtained in the powder form and mixed with oil and a little dryer at the time the pipe is to be made up. Get a clean piece of glass on which to prepare the lead. The tooth brush should be laid on the glass after applying the lead, *to avoid getting grit on the brush* and paint on the table. When grit becomes mixed with the lead it prevents close contact of the filling and pipe thus making the joint less efficient.

The ordinary pipe fitter, when called upon to put up piping that will be subjected to a pressure of 200 to 300 lbs. of steam, feels that he is shouldering a heavy responsibility, but should be called upon to make joints that would have to bear 1,000 lbs. air pressure, he might not feel like assuming the responsibility at all. Again, if he undertake the work, probably he would feel certain that it would be necessary to resort to extraordinary

means to get the desired results. No doubt he would decide that with the ordinary material manufactured and supplied to the general market, such work under these conditions is impossible. Tight joints may be easily made for 1,000 lbs. air pressure when the work is correctly done.

Ques. What is the secret of making tight joints?

Ans. 1, *The threads should be* ***clean,*** 2, the best lubricant should be used to prevent friction, and 3, in making up the joint it should not be screwed up fast enough to make any appreciable change in the temperature of the metal.

When these conditions obtain, the metal may be brought together as solidly as possible, which, as must be evident, is necessary to obtain a tight joint. The friction mentioned in 2, is due to the large amount of bearing surface, especially when there is grit in the threads and the metal is coming solidly together.

NOTE.—***Pipe cement*** for iron or brass: 1 lb. No. 2 Sylvan cup grease; 35 lbs. white lead; 8 lbs. ground graphite.

NOTE.—***For grinding dies*** use Norton Alundum wheel 36-P.

NOTE.—***Foreign pipe threads.*** According to W. J. Baldwin on the practice of Germany and France (comparing the German and French systems with the Briggs system), Germany uses straight threads nearly altogether. The pitch and form of thread is about the same as the English except that the thread as a whole is not tapered. France is more irregular in practice, the Navy following one method and private shops other methods. The French Navy, however, leans toward tapered threads. South American countries have no fixed standards, but import from the United States and England and use the method of the country from which they import. Canada uses the Briggs standard. In Mexico a great deal of American pipe and fitting are used, but Mexico and the South and Central American countries use the methods of those from whom they buy as a rule.

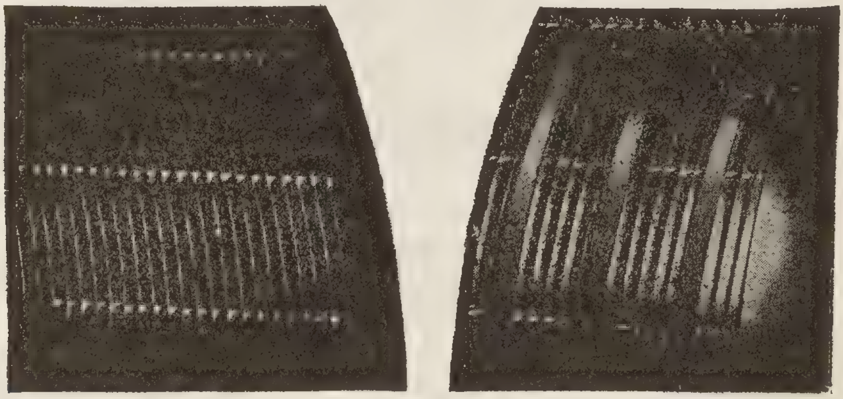
NOTE.—***The bursting pressure*** of screwed fittings is from ten to twenty times the working pressure. The internal fluid pressure is not the determining factor, as fittings must withstand the strain of expansion, contraction, weight of piping, settling and water hammer and there is also the possibility of variation in thickness. ***For cast iron*** *the bursting pressure is generally in excess of* ***1,000 lbs., and for malleable iron,*** *it is in excess of* ***2,000 lbs.***

NOTE.—***A good cement*** for making tight joints in pumps, pipes, etc., is made of a mixture of 15 parts of slaked lime, 30 parts of graphite, and 40 parts of barium sulphate. The ingredients are powdered, well mixed together, and stirred up with 15 parts of boiled oil. A stiffer preparation can be made by increasing the porportions of graphite and barium sulphate to 30 and 40 parts respectively, and omitting the lime. ***Another cement,*** for the same purpose consists of 15 parts of chalk and 50 of graphite, ground, washed, mixed, and reground to fine powder. To this mixture is added 20 parts of ground litharge, and the whole mixed to a stiff paste with about 15 parts of boiled oil. This last preparation possesses the advantage of remaining plastic for a long time when stored in a cool place. Finally, a good and simple mixture for tightening screw connections is made from powdered shellac dissolved in 10 per cent. ammonia. The viscid mass is painted over the screw threads, after the latter have been thoroughly cleaned and the fitting is screwed home. The ammonia soon volatilizes, leaving behind a mass which hardens quickly, makes a tight joint, and is impervious to hot and cold water.

Friction, as previously stated, produces heat, and heat produces expansion, hence, as the pipe is lighter than the fitting, it expands more and therefore, when both become cold, the pipe contracts more than the fitting, thus causing a tendency to leak.

Ques. Are especially long threads favorable for tight joints?

Ans. No (See fig. 8,316 for correct length).



FIGS. 8,314 and 8,315.—Crane experiments on defects in threads. A piece of eight-inch pipe was threaded for a distance of two and a quarter inches. This pipe was then put in a lathe and was mutilated, as shown. In the threaded part, three grooves were turned, each 3/16 of an inch wide and to the bottom of the thread. The top of the remaining threads with the exception of the one at the end of the pipe, were turned off, giving them a flat surface, 1/32 of an inch wide. Next, at three places on the circumference of the tapered thread, flat spots were filed, one inch wide and two inches long, extending one inch on the threaded part, Twenty-five grooves were then filed in the thread of the pipe and the same number in the coupling, all parallel with the pipe and two-thirds of the depth of the thread. When all this deliberate mutilating was finished the threads were cleaned thoroughly and coated with cement. The joint was then screwed up so that the lengthwise grooves did not come opposite one another. The outer ends of the pipe and coupling next were plugged and the joint was tested to 425 pounds of air pressure. The joint was found to be tight, and the same result followed a hydraulic pressure test of 1,000 pounds. The amount of defect in the thread of this joint was at least one hundred times greater than that for which many regular steam fitters and engineers reject material. These tests show the amount of ignorance there has been in these matters all these years. Crane Co. reasoned this subject out, and, confident the public held a wrong theory, caused this experiment to be made. Undoubtedly the amount of material rejected for minor and wholly unimportant defects in the past, must have cost the trade many thousands of dollars.

According to the Crane Co., the larger the thread, the more the tendency to friction, which prevents close contact of the metal, not to mention the natural irregularlity in the threads acting in the same manner. For instance, if an attempt be made to make a joint on say 8 in. pipe with a thread 6

inches long, the friction and irregularities would be so great that it would be practically impossible to get the requisite thread contact.

Ques. Does the absence of heat in making up insure a tight joint?

Ans. No.

It should be understood that the absence of heat in making up does not mean the absence of grit or gum in the threads. Dirty threads may be screwed up very slowly and thus avoid the heating due to friction, and yet the joint will be anything but tight. To guard against this, after cutting the threads, *they should be* ***thoroughly cleaned*** with a stiff brush.

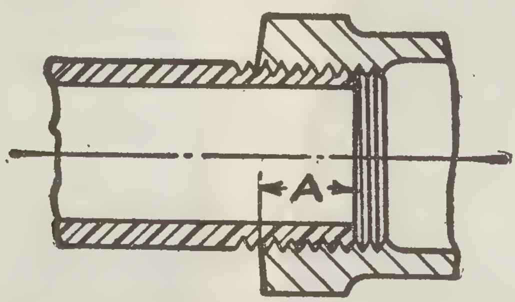


Fig. 8,316.—Screwed joint made up showing length A, of thread on pipe that is screwed into valves or fittings to make a tight joint, according to table by Crane Co. on page 2,131.

Ques. Are perfect threads necessary to make tight joints?

Ans. No.

It is surprising what erroneous ideas are held regarding the placing of too much importance on defects in threads of pipe and fittings, even by experienced pipe fitters. One of the causes assigned for the rejection of pipe and material is that the threads are a trifle broken. Probably not over 1 per cent of the bearing of the thread is gone or marred, yet there are many pipe fitters who will throw out such material. Experiments made by the Crane Co., as in figs. 8,314 and 8,315, show how absurd it is to discard such material.

Ques. In taking measurements for pipe lengths what allowance must be made?

Ans. An allowance for the length of thread that is screwed into valves or fittings to make a tight joint as shown in fig. 8,316

The following table gives such allowance for various sizes of pipe.

Length of Thread on Pipe

Size inches	Dimension A inches	Size inches	Dimension A inches	Size inches	Dimension A inches	Size inches	Dimension A inches
1/8	1/4	1	9/16	3	1	6	1 1/4
1/4	3/8	1 1/4	5/8	3 1/2	1 1/16	7	1 1/4
3/8	3/8	1 1/2	5/8	4	1 1/16	8	1 5/16
......	......	......	......	......	......	9	1 3/8
1/2	1/2	2	11/16	4 1/2	1 1/8	10	1 1/2
3/4	1/2	2 1/2	15/16	5	1 3/16	12	1 5/8

(Necessary to make a tight joint. Dimensions A, fig. 8,316.)

Example of Pipe Fitting.—The piping system of the author's launch, ***"Stornoway,"*** as shown in fig. 8,317, is an illustration of an installation comprising numerous lengths of pipe and a multiplicity of fitting, and most of it being located below the floor timbers of a small boat presents some difficulty which taxes the ingenuity of the fitter. The boat being operated in salt water, brass pipe and fittings are used to prevent rapid corrosion, except the exhaust pipe, which is of copper with flanged joints.

There are two methods by which the pipe fitting may be done:

1. By eye and approximate measurements, or
2. Entirely by measurements.

The first method is a hit or miss process and requires an experienced fitter to make a good job, whereas, the second method is one of precision and is the better way of doing it because in making up the various lines it is not necessary to bring undue strain on them by springing them into position to correct small errors in cutting to wrong lengths.

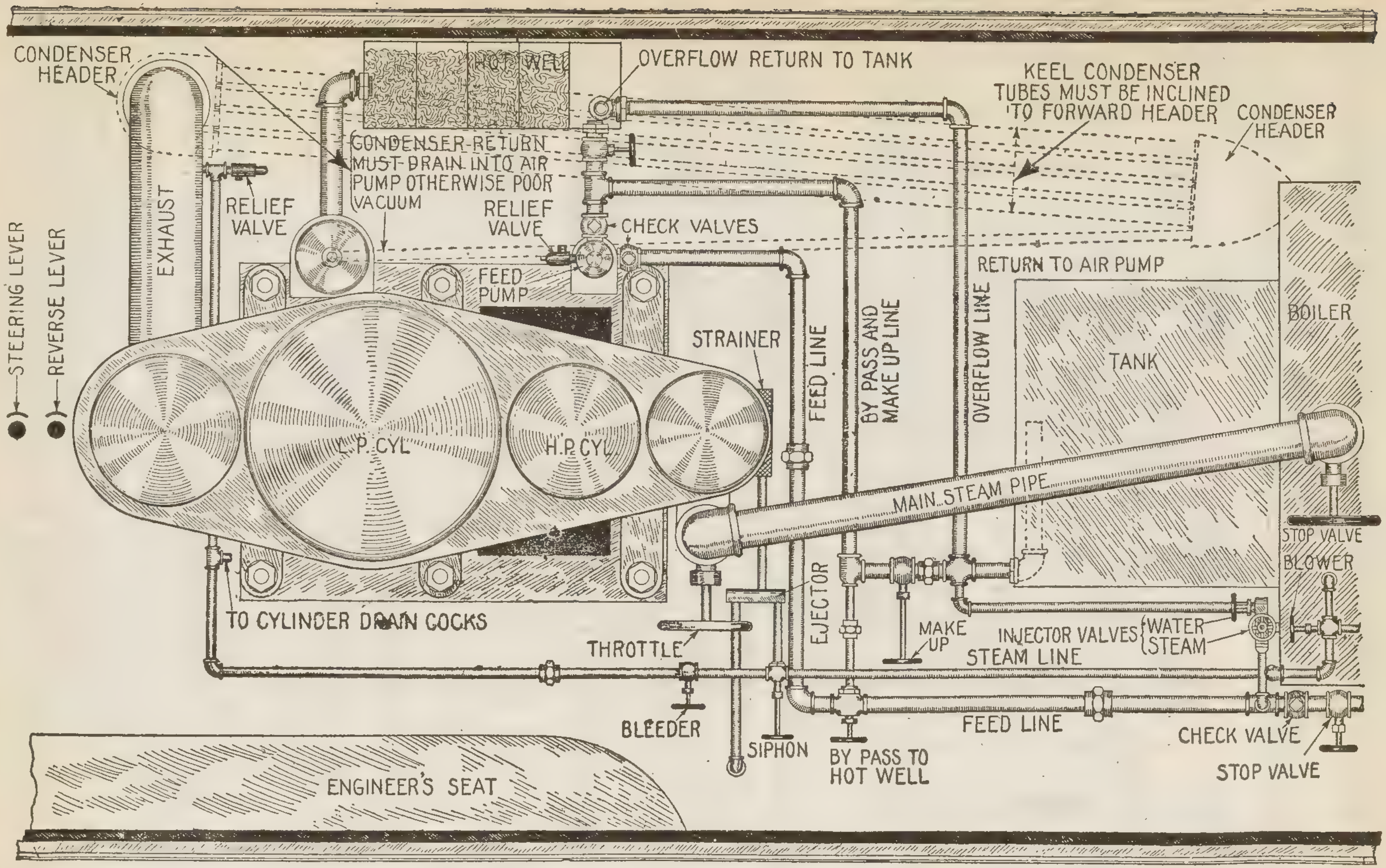


FIG. 8,317.—***General arrangement of machinery and piping of the author's steamer "Stornoway I."*** With the control arranged as here shown, a boat of considerable size can be operated by one man. ***Note position:*** 1, of throttle, reverse and steering levers; 2, of by pass, make up, syphon, and bleeder valves, all within reach of engineer's seat; 3, of tank under boiler where water absorbs some heat from ash pan. ***With keel condenser,*** the tubes and return pipe *must* be inclined so *condensate will drain from condenser inlet to air pump, otherwise* ***little or no vacuum.*** Relief valves should be placed on exhaust and feed lines. ***In piping,*** use plenty of unions and avoid special fittings. Injector steam pipe should have separate boiler connection.

In actual practice a combination of the two methods will save time and give satisfactory results. Thus, where there is a little margin for adjustment in making up a line, as for instance, the pump lines to hot well with their lock nut joints, such lines can be proportioned "by eye."

The pipe fitting for the installation shown in fig. 8,330, should be done about as follows:

Place the hot well in position close to the side of the boat. Now make up the short line between the feed pump and hot well, proportioning the two

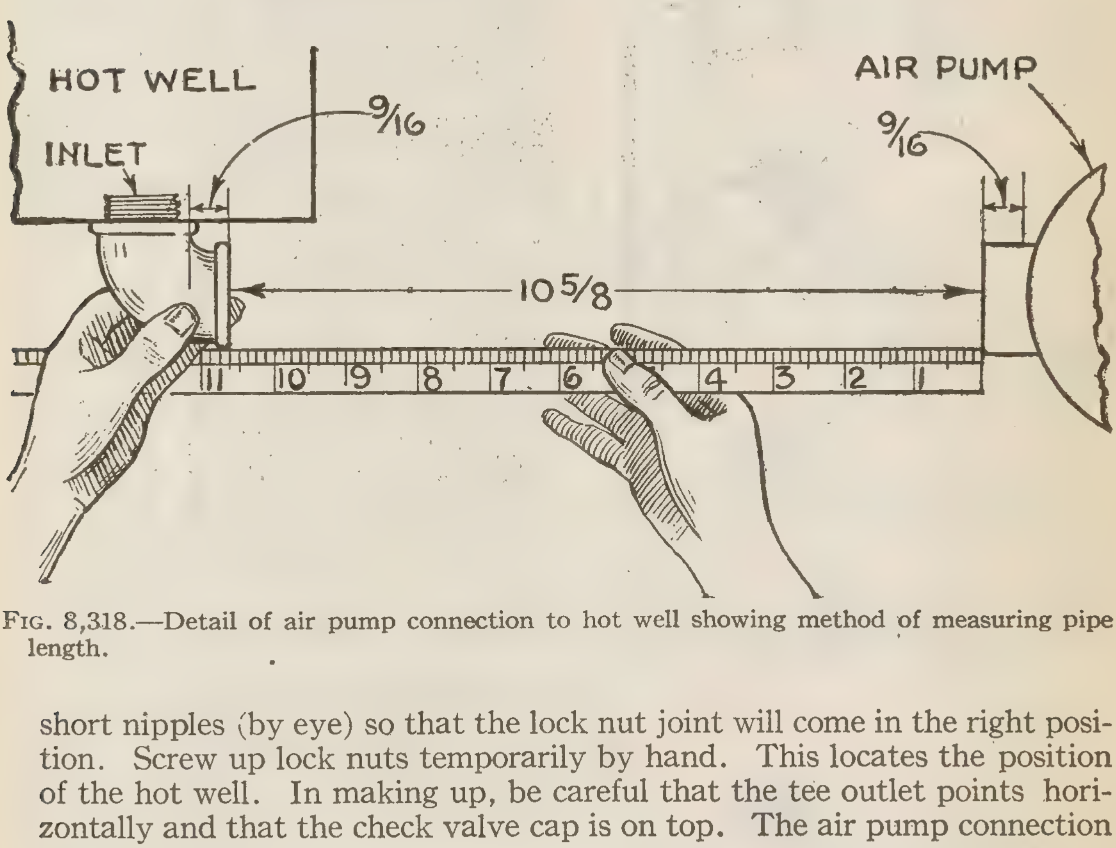
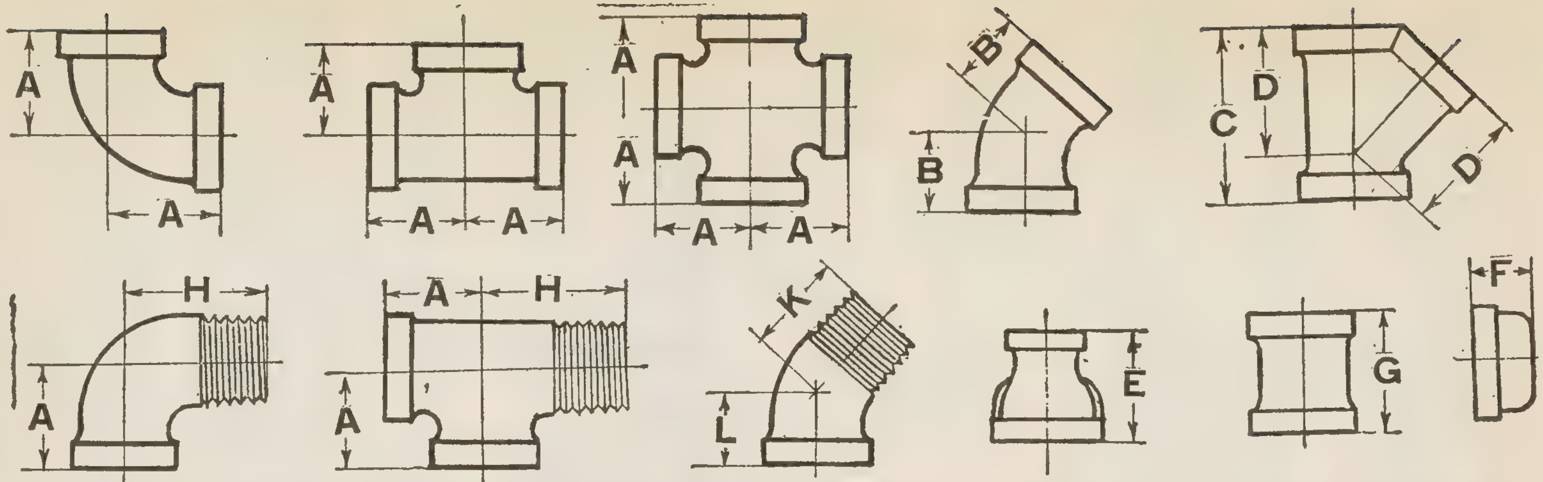


FIG. 8,318.—Detail of air pump connection to hot well showing method of measuring pipe length.

short nipples (by eye) so that the lock nut joint will come in the right position. Screw up lock nuts temporarily by hand. This locates the position of the hot well. In making up, be careful that the tee outlet points horizontally and that the check valve cap is on top. The air pump connection should be made next.

To get the length of the pipe, hold the elbow up against the inlet hole in end of hot well and measure from the face of air pump connection, to the face of elbow as shown in fig. 8,318. Now the size of the pipe being one inch, a margin of $^{9}/_{16}$ in. must be allowed, according to table on page



FIGS. 8,319 to 8,329.—General dimensions of Crane standard malleable iron screwed fittings. The reference letters refer to the table below.

Size......Inches	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6
Size......Millimeters	3	6	10	13	19	25	32	38	50	64	76	90	100	113	125	150
A......Inches	11/16	13/16	15/16	1 1/8	1 5/16	1 7/16	1 3/4	1 15/16	2 1/4	2 11/16	3 1/8	3 7/16	3 3/4	4 1/16	4 7/16	5 1/8
B......Inches		3/4	13/16	7/8	1	1 1/8	1 5/16	1 7/16	1 11/16	1 15/16	2 3/16	2 3/8	2 5/8	2 13/16	3 1/16	3 7/16
C......Inches			2 1/8	2 1/2	2 7/8	3 7/16	4 1/16	4 1/2	5 7/16	6 1/4	7 1/4		8 7/8			
D......Inches			1 7/16	1 11/16	2	2 7/16	2 15/16	3 5/16	4 1/16	4 11/16	5 9/16		6 15/16			
E......Inches		1	1 1/8	1 1/4	1 7/16	1 11/16	2 1/16	2 5/16	2 13/16	3 1/4	3 11/16	4	4 3/8			
F......Inches	17/32	5/8	3/4	7/8	1 1/16	1 3/16	1 1/4	1 5/16	1 7/16	1 5/8	1 3/4	1 15/16	2		2 5/16	2 9/16
G......Inches		1 1/16	1 3/16	1 5/16	1 1/2	1 11/16	1 15/16	2 1/8	2 1/2	2 7/8	3 3/16					
H......Inches	1 1/8	1 5/16	1 7/16	1 5/8	1 7/8	2 1/8	2 1/2	2 11/16	3 3/16	3 13/16	4 1/2		5 11/16			
K......Inches		15/16	1 1/16	1 3/16	1 5/16	1 1/2	1 11/16	1 7/8	2 1/4		3		3 3/4			
L......Inches		5/8	11/16	13/16	15/16	1 1/16	1 1/4	1 3/8	1 11/16		2 1/8		2 1/2			

2,131 in order to make a tight joint; total length of pipe is $10\frac{3}{8}+2\times{}^{9}/_{16}=11\frac{3}{4}$.

Cut pipe to 13¾ ins. in length and thread each end. Screw elbow on one end before taking pipe out of vise. The pipe is screwed into air pump outlet and on the last turn bring elbow fair with hole in hot well. Unscrew lock nut on feed pump connection and remove hot well. Screw into elbow a close nipple with long thread at the other end, with one lock nut screwed on. Now replace hot well and make up permanently the two lock nut joints, using gaskets or packing and red lead to make tight joints.

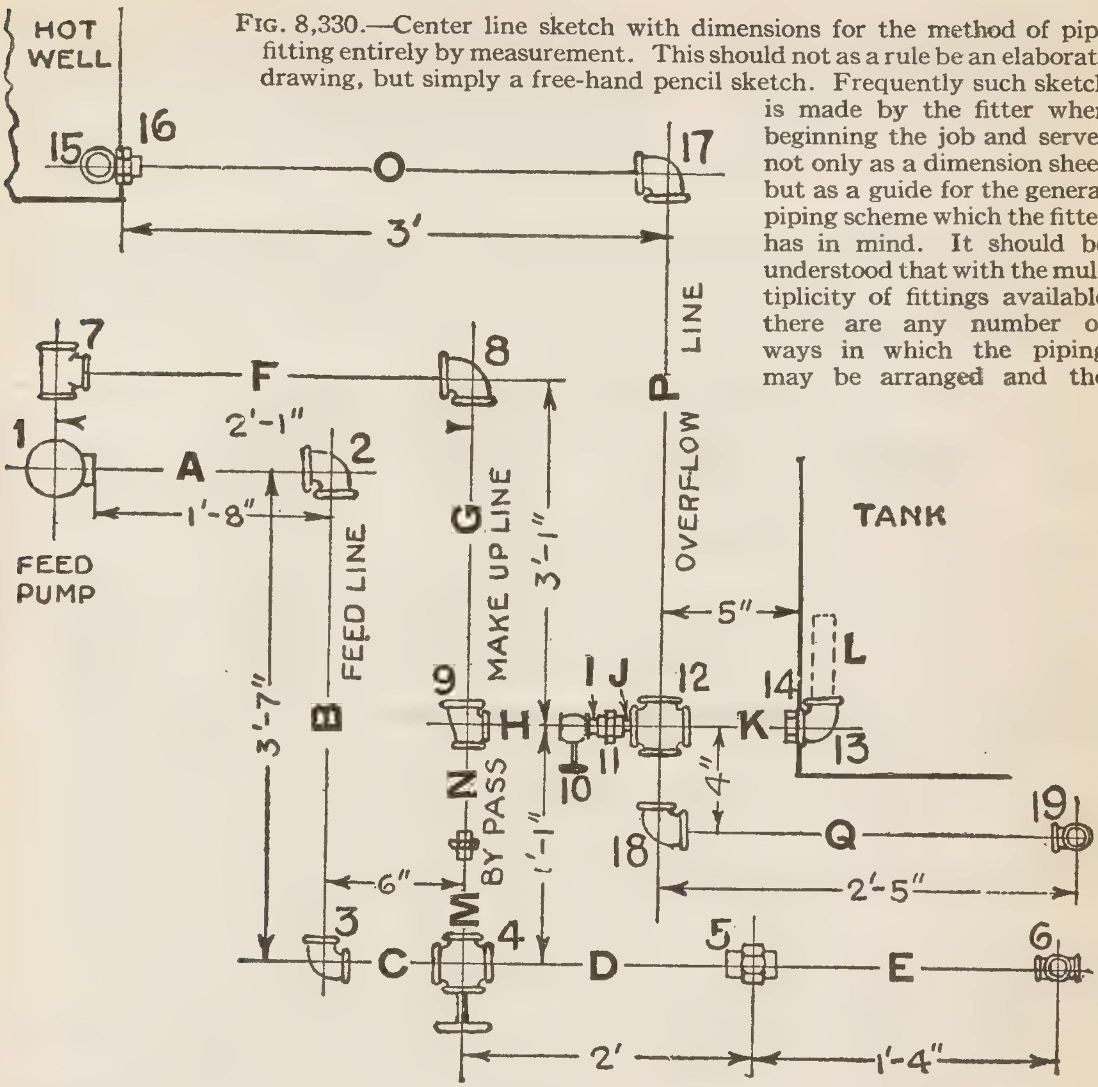
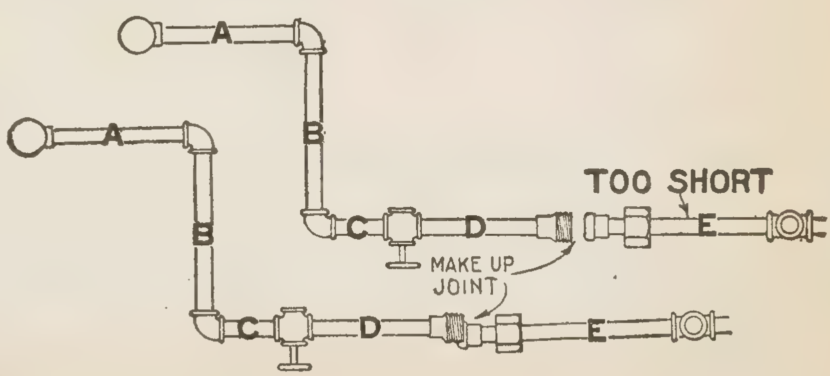


FIG. 8,330.—Center line sketch with dimensions for the method of pipe fitting entirely by measurement. This should not as a rule be an elaborate drawing, but simply a free-hand pencil sketch. Frequently such sketch is made by the fitter when beginning the job and serves not only as a dimension sheet but as a guide for the general piping scheme which the fitter has in mind. It should be understood that with the multiplicity of fittings available there are any number of ways in which the piping may be arranged and the fitter's ability may be judged by the general arrangement of piping which he adopts.



FIGS. 8,331 and 8,332.—Detail of feed line ready to "make up." Fig. 8,331 shows *poor workmanship*, nipple E, being too short rendering it difficult to bring together the make up joint. Fig. 8,332 shows *good workmanship*; here the male end of the union will easily spring back into position in making up the joint.

In order to avoid frequent change of dies in the stock, it is well to make up lines of one size when it can be conveniently done, before taking up another size; this avoids variations due to readjustment of dies when adjustable dies are used. Accordingly the feed, make up, and overflow lines being of the same size, these should be made up before changing the dies.

Make a center line sketch of these lines with dimensions as in fig. 8,330. Pipe up first the feed line. This line as shown consists of pipes A,B,C, D,E, pump connection 1, and fittings 2,3,4,5 and 6. Now determine overall dimensions of A,B,C,D,E, thus:

Pipe	Distance between centers	Fitting number	Center to face of fitting inches (subtract)	Allow for threads inches (add)	Overall length pipe
A	1′ 8″	2	1 5/16	1/2	19 11/16
B	3′ 7″	3	1 5/16	1/2	44 5/8
C	6″	4	*1 5/8	1/2	4 1/16
D	2′	5	*1 1/16	1/2	22 1/4
E	1′ 4″	6	1 5/16	1/2	14 5/8

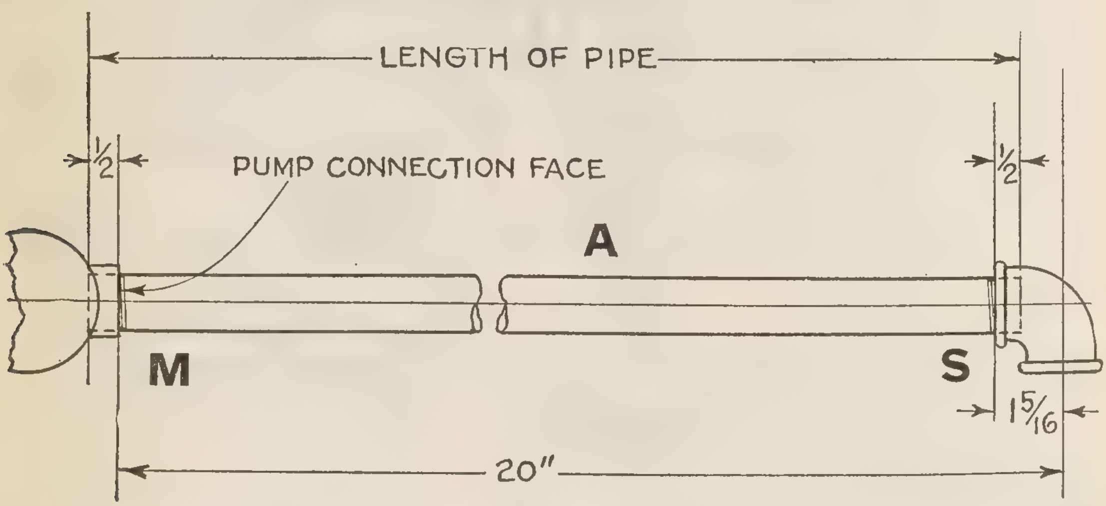


FIG. 8,333.—Detail of a portion of the feed line showing method of determining length of pipe A.

Figs. 8,319 to 8,329 show standard malleable iron screwed fittings, the reference letters indicating the general dimensions in the accompanying table:

To determine overall dimensions of pipe A, note in fig. 8,330 the distance between pump connection face and center of elbow 2, is 1 foot 8 inches, or

20 inches, as shown in detail in fig. 8,333. From table (page **2,136**), the distance from center of fitting 2, to face is 1 1/16 inches and from table (page **2,136**), length of thread which must be screwed into fitting to make a tight joint is (for 3/4 inch pipe) 1/2 inch. Accordingly, from fig. 8,330 the length of pipe A, is clearly:

$$\left.\begin{array}{c}\text{Pump connections face}\\ \text{to}\\ \text{center of fitting 2}\end{array}\right\} + \text{thread at M} - \left\{\begin{array}{c}\text{center to face}\\ \text{of fitting}\end{array}\right\} + \text{thread at S} = \text{length of pipe}$$

$$20 \quad + \quad \tfrac{1}{2} \quad - \quad 1\tfrac{5}{16} \quad + \quad \tfrac{1}{2} \quad = \quad 19\tfrac{11}{16}$$

Similarly for pipe B:

$$\left.\begin{array}{c}\text{Distance between}\\ \text{center fittings}\\ \text{2 and 3}\end{array}\right\} + \left\{\begin{array}{c}2\times\text{center to face}\\ \text{of fitting}\end{array}\right\} - 2\times\text{thread} = \text{length of pipe}$$

$$43 \quad + \quad 2\times1\tfrac{5}{16} \quad - \quad 2\times\tfrac{1}{2} = \quad 44\tfrac{5}{8}$$

In like manner the lengths of pipes C, D, E, are obtained.

Cut and thread all these pipes except pipe E. Start at the feed pump and make up the line up to D, including end *x*, of union 5.

Now with the union screwed together temporarily, measure the distance between faces of the union 5 and tee 6. The sum of this distance plus the distances from center to face of fittings will probably vary a little from the dimension 1 foot 4 inches, due to inaccuracies in make up and cutting. Hence, to avoid strain on the line (assuming tee 6, fig. 8,330) to be fixed, make length of pipe E, equal to measured distance between faces of fittings plus 1 inch margin for both threads.

After cutting threads on both ends of pipe E, screw on the *y* end of union 5, while the pipe is in the vise. If *y*, be the ring end of the union, be sure the ring is on before screwing the pipe into tee 6. To make up the union spring both ends into place and screw on the ring firmly, thus completing the feed line.

NOTE.—***Pipe practice*** or *customs of the trade*: On orders calling for commercial sizes of pipe to be furnished with threads and couplings in sizes 1/2 to 12 inch, inclusive, where orders specify quantity in lineal feet it is understood that random lengths, threaded both ends, with coupling on one end, will be shipped, and the measurement is charged from end to end, that is, over all including coupling. Orders or inquiries covering cut lengths of any size should specify whether plain ends, threads only, threads and couplings, or flanges are required. A separate charge is made for couplings or flanges, either loose or screwed on pipe, when pipe is ordered cut to specified lengths.

In a similar manner next pipe up the make up line. Start at tee 7, and make up the line to reducing tee 9. If the measurements and work be accurate, this tee should be in alignment with by pass valve 4; if much out, the length of pipe F, must be changed. Get two short nipples I and J, and make up the section consisting of these nipples, valves 10 and 12, and union 11. Cut and thread pipe K, and make up the line from valve 10 to pipe L. See that the valves point right and pipe L, to the bottom of the tank.

Next pipe up the overflow line from valve 12 to overflow pipe 15, in hot well. The lock nut 14, should now be firmly screwed up against packing to make a water tight joint. Pipe H, can now be measured, cut and threaded. Before removing it from the vise unscrew ring of union 11, and screw on valve 10. Remove from vise and screw the other end of pipe H, into tee 9. Spring into place and make up union 11, thus completing the line.

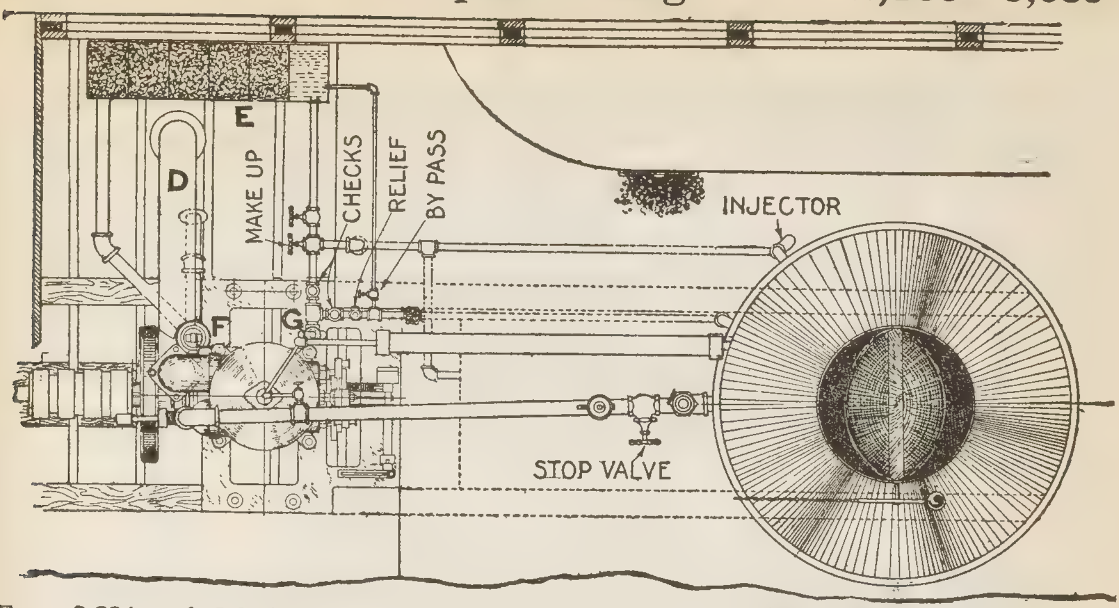
After all the ¾-inch piping has been installed, change dies to ½ inch size.

First find by measure length of pipe M and N. Cut, thread and make up the by pass line. If the work has been accurate, there should be no trouble in making up union 20. The rest of the screwed piping is put together in a similar manner.

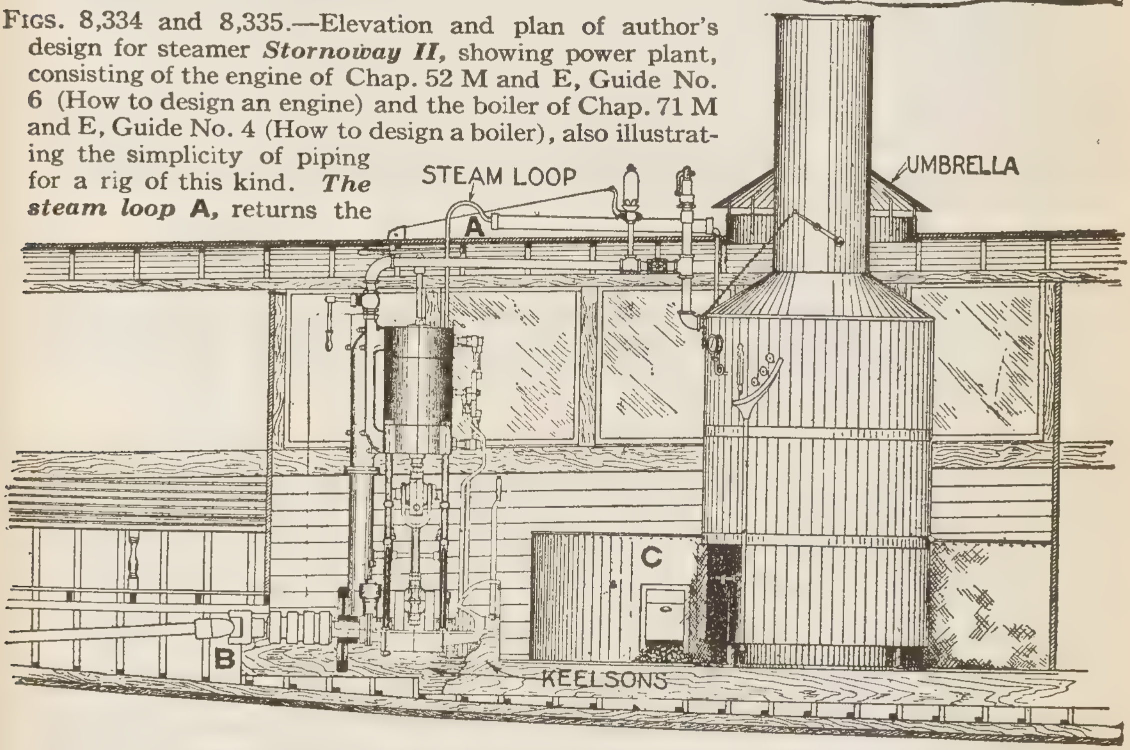
The exhaust pipe is of copper bent to template, with flanged connection at each end. The condenser tubes are made tight by stuffing boxes in the headers. The return to air pump is standard weight pipe with screw joints.

Fig. 8,317 shows the main steam pipe with an elbow connecting the horizontal with the vertical length; a better job would consist of bending the pipe in place of elbows. This should preferably be done with proper facilities at the shop, unless the fitter be experienced in bending and has proper facilities at hand.

NOTE.—***Pipe practice or customs of the trade.*** Orders for pipe larger than 12 in. should specify the actual outside diameter of the pipe and the thickness of the wall. Standard weight pipe is listed and carried in stock threaded and coupled and will be shipped unless order specified otherwise. Extra strong, double extra strong, hydraulic, and large *o.d.* pipe is listed plain ends only and will be so shipped unless order specifies otherwise. An extra charge is made for threads and couplings on these weights. For pipe smoothed on the inside, known as reamed and drifted, an extra charge is made. Such pipe is furnished in random lengths 20 feet and shorter. Random lengths of extra strong and double extra strong pipe are considered to be 12 to 22 feet, dealer to have privilege of supplying not to exceed 5 per cent of total order in lengths 6 to 12 feet. For cut lengths of any size an extra charge above random lengths will be made. For galvanized or asphalted pipe an extra charge above black will be made. Sizes 8, 10 and 12 inch standard pipe are listed in several weights and orders or inquiries should specify the weight required.



FIGS. 8,334 and 8,335.—Elevation and plan of author's design for steamer ***Stornoway II,*** showing power plant, consisting of the engine of Chap. 52 M and E, Guide No. 6 (How to design an engine) and the boiler of Chap. 71 M and E, Guide No. 4 (How to design a boiler), also illustrating the simplicity of piping for a rig of this kind. ***The steam loop* A,** returns the



jacket condensate to boiler. ***Its successful operation*** will depend upon sufficient length of *drop leg* to balance the difference of pressure between boiler and *riser*. **B,** universal joint; **C,** coal bunker; **D,** exhaust pipe; **E,** hot well; **F,** air pump; **G,** feed pump. ***With keel condenser,*** the tubes and return pipe *must* be inclined so ***condensate will drain from condenser inlet to air pump, otherwise little or no vacuum.*** (See author's method page 3,131 M and E Guide No. 7). Relief valve should be placed on feed line. ***In piping,*** a *liberal number of unions* should be used and special fittings avoided. There should be valves next to boiler on feed and main steam lines. The injector should receive its steam from separate connection to boiler instead of from main steam pipe.

Size of Steam Pipes.—This is governed by the velocity of steam within them and by the radiation. As the size decreases, the steam velocity and the pressure drop for a given quanity naturally increases; on the other hand, the larger the pipe, the greater the radiation and the greater the amount of condensation; hence the designer has to intelligently consider these opposing effects. In practice the limiting factor in the velocity advisable is the allowable pressure drop between the boiler and the engine.

Strength of Pipes.—Careful judgment must be exercised by the designer in determining the strength or weight of pipes to be used and sufficient allowances made for the pressure and temperature, size of mains and branches, expansion and contraction, water hammer, vibration, settling and corrosion.

Since the effects of the disturbing influences can only be assumed, a high factor of safety should be employed. For steam mains it should never be less than 6, even under the most favorable conditions; and where the stresses due to the various forces are likely to be severe, a factor as high as 15 may be employed to advantage.

Condensation and Water Hammer.—With the proper size and strength of pipe determined, the most important factor is the prevention of water pockets and the removal of water of condensation that will occur in any system. Water is practically incompressible, and its action when traveling at high velocities differs little from that of a solid body of equal weight, hence impact against elbows, valves or other obstructions is the equivalent of a heavy hammer blow that may result in a disastrous fracture of the fitting or pipe.

To Avoid Water Hammer, the installation of efficient means

COMPARISON OF WROUGHT PIPE WITH NEAREST SIZES OF "SHELBY" SEAMLESS STEEL TUBING

STANDARD

Nominal Size Inside Diameter of Standard Wrought Pipe: Size	O. D.	Nominal Weight Per Foot	Nominal Thickness of Wall	Nearest Fractional Size of Seamless: O. D.	Thickness
1/8	.405	244	.068	13/32	16 Ga.
1/4	.540	.424	.088	17/32	14 Ga.
3/8	.675	.567	.091	21/32	13 Ga.
1/2	.840	.850	.109	27/32	12 Ga.
3/4	1.050	1.130	.113	1 1/16	12 Ga.
1	1.315	1.678	.133	1 5/16	10 Ga.
1 1/4	1.660	2.272	.140	1 5/8	9 Ga.
1 1/2	1.900	2.717	.145	1 7/8	9 Ga.
2	2.375	3.652	.154	2 3/8	5/32
2 1/2	2.875	5.793	.203	2 7/8	6 Ga.
3	3.500	7.575	.216	3 1/2	7/32
3 1/2	4.000	9.109	.226	4	4 Ga.
4	4.500	10.790	.237	4 1/2	4 Ga.
4 1/2	5.000	12.538	.247	5	1/4
5	5.563	14.617	.258	5 5/8	9/32
6	6.625	18.974	.280	6 5/8	9/32

EXTRA STRONG

Nominal Size Inside Diameter of Extra Strong Pipe: Size	O. D.	Normal Weight Per Foot	Nominal Thickness of Wall	Nearest Fractional Size of Seamless: O. D.	Thickness
1/8	.405	.314	.095	13/32	13 Ga.
1/4	540	.535	.119	17/32	11 Ga.
3/8	.675	.738	.126	11/16	1/8
1/2	.840	1.087	.147	27/32	9 Ga.
3/4	1.050	1.473	.154	1 1/16	5/32
1	1.315	2.171	.179	1 5/16	7 Ga.
1 1/4	1.660	2.996	.191	1 11/16	3/16
1 1/2	1.900	3.631	.200	1 7/8	6 Ga.
2	2.375	5.022	.218	2 3/8	7/32
2 1/2	2.875	7.661	.276	2 7/8	9/32
3	3.500	10.252	.300	3 1/2	1
3 1/2	4.000	12.505	.318	4	5/16
4	4.500	14.983	.337	4 1/2	11/32
4 1/2	5.000	17.611	.355	5	11/32
5	5.563	20.778	.375	5 9/16	3/8
6	6.625	28.573	.432	6 5/8	7/16

DOUBLE EXTRA STRONG

Nominal Size Inside Diameter of Double Extra Strong Pipe: Size	O. D.	Nominal Weight Per Foot	Nominal Thickness of Wall	Nearest Fractional Size of Seamless: O. D.	Thickness
1/2	.840	1 714	.294	27/32	19/64
3/4	1.050	2.440	.308	1 1/16	5/16
1	1.315	3.659	.358	1 5/16	23/64
1 1/4	1.660	5.214	.382	1 11/16	25/64
1 1/2	1.900	6.408	.400	1 7/8	13/32
2	2.375	9.029	.436	2 3/8	7/16
2 1/2	2.875	13.695	.552	2 7/8	9/16
3	3.500	18.583	.600	3 1/2	19/32
3 1/2	4.000	22.850	.636	4	5/8
4	4.500	27.541	.674	4 1/2	11/16
4 1/2	5.000	32.530	.710	5	23/32
5	5.563	38.552	.750	5 5/16	3/4
6	6.625	53.160	.864	6 5/8	7/8

WROUGHT STEEL PIPE

THEORETICAL BURSTING AND WORKING PRESSURES POUNDS PER SQUARE INCH

Size	Size	Standard		Extra Strong		Double Extra Strong		Large O. D.			
Inches	Millimeters	Bursting Pressure Barlow's Formula	Working Pressure Factor 8	Bursting Pressure Barlow's Formula	Working Pressure Factor 8	Bursting Pressure Barlow's Formula	Working Pressure Factor 8	3/8 Inch Thick Bursting Pressure Barlow's Formula	Working Pressure Factor 8	1/2 Inch Thick Bursting Pressure Barlow's Formula	Working Pressure Factor 8
1/8	3	13,432	1679	18,760	2345						
1/4	6	13,032	1629	17,624	2203						
3/8	10	10,784	1348	14,928	1866						
1/2	13	10,384	1298	14,000	1750	28,000	3500				
3/4	19	8,608	1076	11,728	1466	23,464	2933				
1	25	8,088	1011	10,888	1361	21,776	2722				
1 1/4	32	6,744	843	9,200	1150	18,408	2301				
1 1/2	38	6,104	763	8,416	1052	16,840	2105				
2	50	5,184	648	7,336	917	14,680	1835				
2 1/2	64	5,648	706	7,680	960	15,360	1920				
3	76	4,936	617	6,856	857	13,714	1714				
3 1/2	90	5,610	701	7,950	994	15,900	1987				
4	100	5,266	658	7,480	935	14,970	1871				
4 1/2	113	4,940	618	7,100	887	14,200	1775				
5	125	4,630	579	6,740	842	13,480	1685				
6	150	4,220	528	6,520	815	13,040	1630				
7	175	3,940	493	6,550	819	11,470	1434				
8	200	3,730	466	5,780	722	10,140	1267				
9	225	3,550	444	5,190	649						
10	250	3,390	424	4,650	581						
12	300	2,940	368	3,920	490						
14	350							2,680	335	3,570	446
15	375							2,500	313	3,333	417
16	400							2,340	293	3,120	390
18	450							2,080	260	2,770	346
20	500							1,870	234	2,500	313
22	550							1,700	213	2,270	284
24	600							1,560	195	2,080	260

In the above table, butt welded pipe was figured on sizes 3 inch and smaller and lap welded pipe sizes 3½ inch and larger.

for removing condensate is imperative, and the following suggestions as to such means may be of service:

1. The pitch of all pipes should be in the direction of the flow of steam.

2. Wherever a rise is necessary a drain should be installed.

3. Main headers and important branches should end in a drop leg, each of which should be connected to the drainage system.

4. All low points in the piping should be drained and a drainage connection should be made to every fitting where there is danger of a water pocket.

5. Branch lines should, where possible, be taken from the top of a main header, but never from the bottom.

6. Valves should be so located that they cannot form water pockets when either open or closed. For this reason globe valves should be set with the stem horizontal.

7. Where valves are placed directly on the boiler nozzle, a drain should be provided at the lowest point above the valve seat.

8. When two valves are installed between a boiler and the main header, a drain should be installed between them.

Steam Pipe Coverings.—When steam pipes are exposed to the air, the steam condenses more or less rapidly, according to the temperature and circulation of the air surrounding them, causing a serious loss not only in the volume of steam, but of efficiency in utilizing the remainder when it reaches the engine. To reduce this loss, steam pipes, heaters, separators, valves, fittings, etc., should be effectively covered with a good heat-insulating material. An efficient covering should not deteriorate seriously from the heat or vibration to which it is subjected, and in all cases where it is necessary to consider the fire risk, should be made of non-combustible substances.

All surfaces to be covered should be painted before the material is applied. To insure lasting economy, pipe coverings must receive the same care and frequent inspection as any other part of a steam plant. Their efficiency quickly falls off if air be permitted to circulate between them and the pipe, and if allowed to become wet they only increase the evil they are expected to remedy.

SEAMLESS DRAWN BRASS AND COPPER TUBING

IRON PIPE SIZES
STANDARD

Size Inches	Size Millimeters	Dimensions: Inside Diameter Inches	Dimensions: Outside Diameter Inches	Approximate Weights: Brass Per Lineal Foot Pounds	Approximate Weights: Copper Per Lineal Foot Pounds
⅛	3	.281	.405	.25	.26
¼	6	.375	.540	.43	.45
⅜	10	.494	.675	.62	.65
½	13	.625	.840	.90	.95
¾	19	.822	1.05	1.25	1.31
1	25	1.062	1.315	1.70	1.79
1¼	32	1.368	1.66	2.50	2.63
1½	38	1.600	1.90	3.00	3.15
2	50	2.062	2.375	4.00	4.20
2½	64	2.500	2.875	5.75	6.04
3	76	3.062	3.50	8.30	8.72
3½	90	3.500	4.00	10.90	11.45
4	100	4.000	4.50	12.70	13.33
4½	113	4.500	5.00	13.90	14.60
5	125	5.062	5.563	15.75	16.54
6	150	6.125	6.625	18.31	19.23
7	175	7.062	7.625	26.28	27.60
8	200	7.982	8.625	29.88	31.37

EXTRA HEAVY

				Brass CODE: RESPONDEAM	Copper CODE: RESPUEMUS
⅛	3	.205	.405	.370	.388
¼	6	.294	.540	.625	.650
⅜	10	.421	.675	.830	.870
½	13	.542	.840	1.200	1.33
¾	19	.736	1.050	1.660	1.75
1	25	.951	1.315	2.360	2.478
1¼	32	1.272	1.660	3.300	3.465
1½	38	1.494	1.900	4.250	4.462
2	50	1.933	2.375	5.460	5.733
2½	64	2.315	2.875	8.300	8.715
3	76	2.892	3.500	11.200	11.760
3½	90	3.358	4.00	13.700	14.385
4	100	3.818	4.50	16.500	17.325
5	125	4.813	5.563	22.800	23.940
6	150	5.750	6.625	32.000	33.600

Furnished with plain ends, unless otherwise specified. Commercial lengths are 12 feet long. 18 foot lengths can be made up on order.

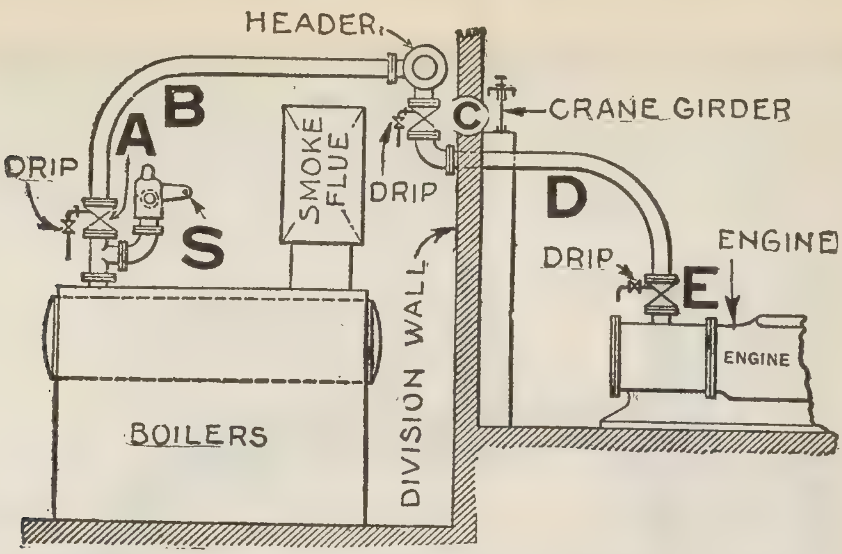


FIG. 8,336.—Objectionable arrangement of piping; it is arranged thus in order to carry the bend D, underneath the crane girder in the engine room. ***It is objectionable*** because when gate valve A, on any boiler, is closed, bend B, will gradually fill with condensate, the column of water being driven over into main when A, is reopened. If engine be cut out of service by closing valve E, leaving C, open; bend D, will fill up with water which will pass into the cylinder when E, is reopened. If both E and C, be closed, water will collect in main above C. Whenever a valve forms a water pocket in a steam line, as A, C, and E, the valves should be drained from above the seat.

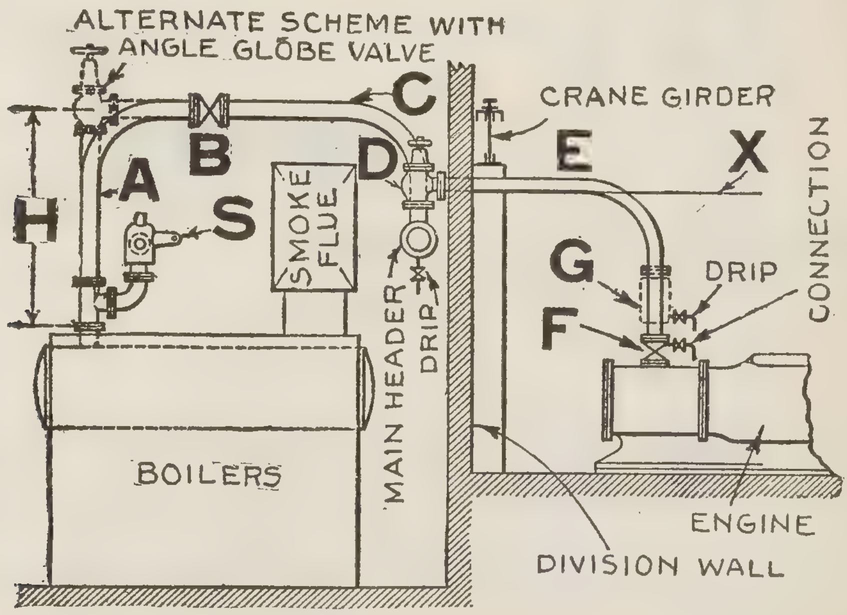


FIG. 8,337.—Proper arrangement of piping. In this arrangement, condensation on bend C, will drain into main; the same result is obtained using angle valve (dotted lines) instead of B. Valves placed at some distance as H, above boiler nozzle should be anchored to prevent vibration. Any leakage through angle valve, or B, will fill bend E, with condensate, hence the necessity of a separator G, placed close to the cylinder.

Expansion and Support of Pipes.—In arranging steam or hot water pipes the greatest care must be taken, particularly with the former, to provide for the variations in length and form, due to temperature changes, without allowing the pipes and fittings

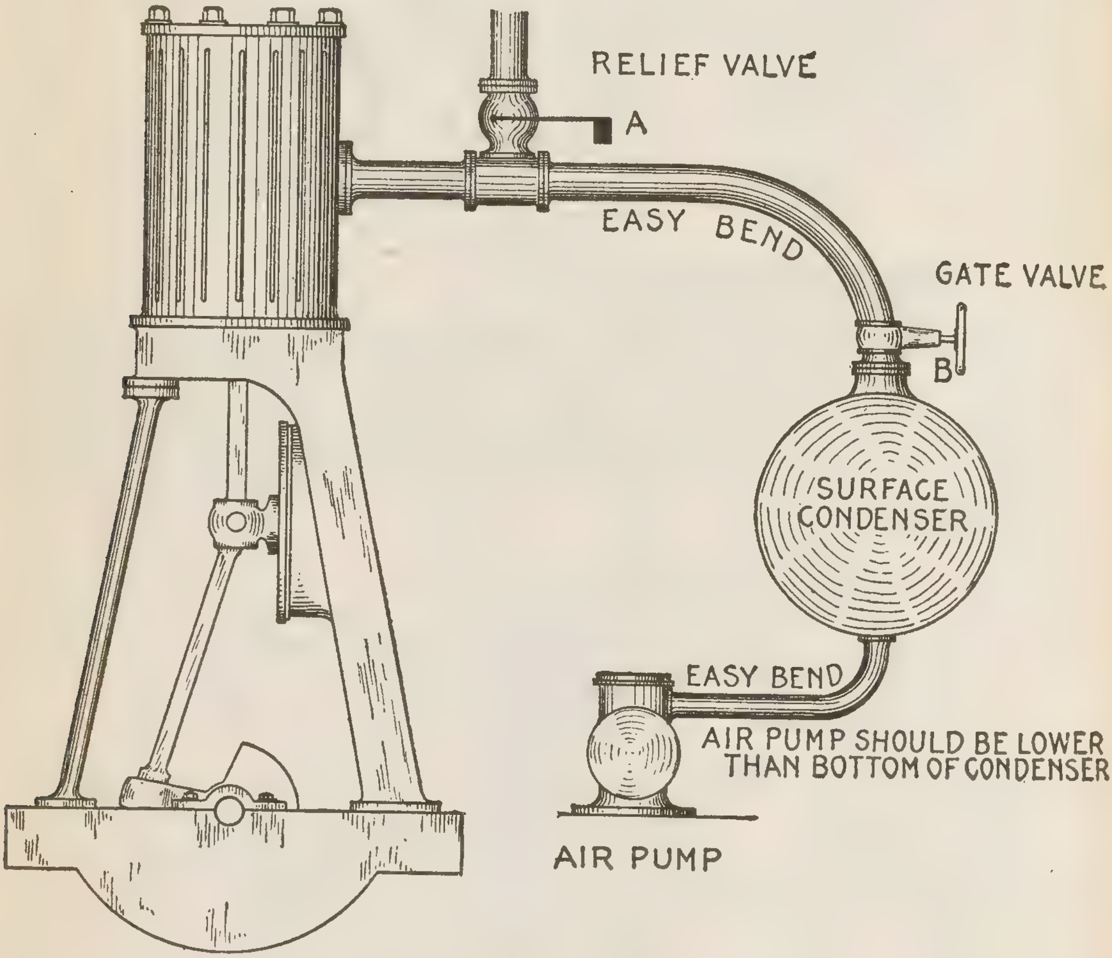
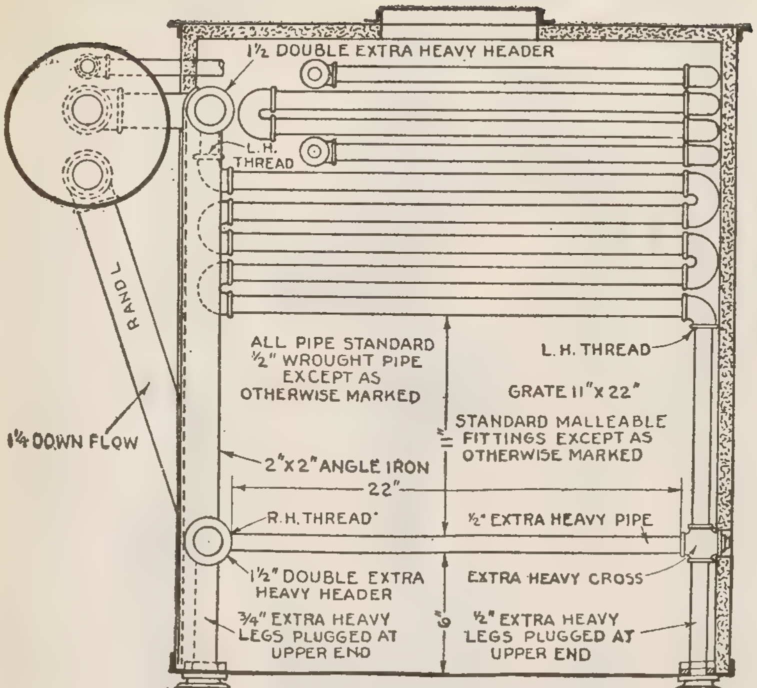
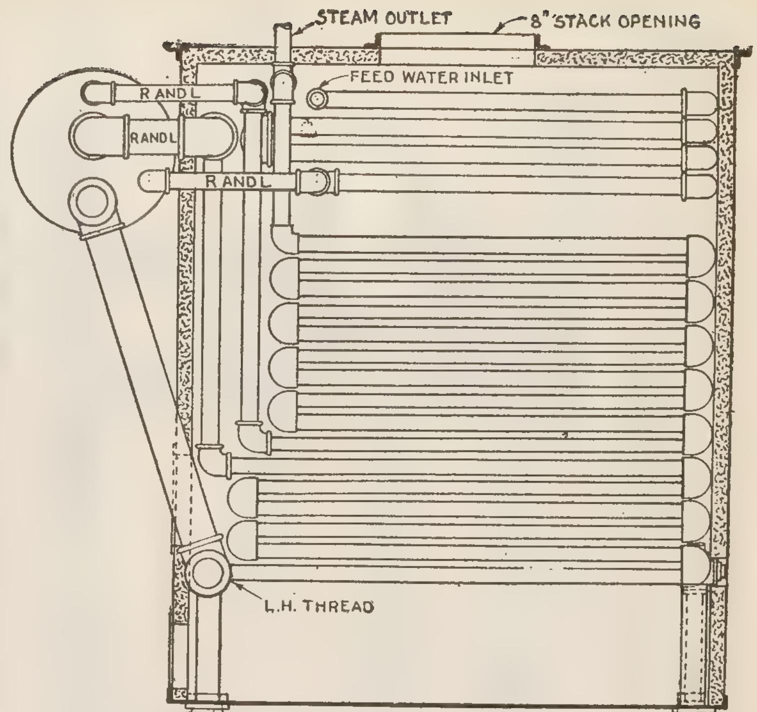


FIG. 8,338.—View of engine and condenser, showing how to arrange the piping to secure good vacuum. *Locate the condenser as near the engine as possible;* ***use easy bends*** *instead of elbows; place the pump* ***below*** *bottom of condenser so the water will drain to pump.* At A, is a relief valve, for protection in case the condenser become flooded through failure of the pump and at B, is a gate valve to shut off condenser in case atmospheric exhaust be desired to permit repairs to be made to condenser during operation. ***A water seal*** should be maintained on the relief valve and ***special attention*** *should be given to the stuffing box* of the gate valve ***to prevent air leakage.*** *The discharge valve of the pump should be water sealed.*

to be subjected to undue strains. At certain points the pipes should be securely anchored, and at other places supports of



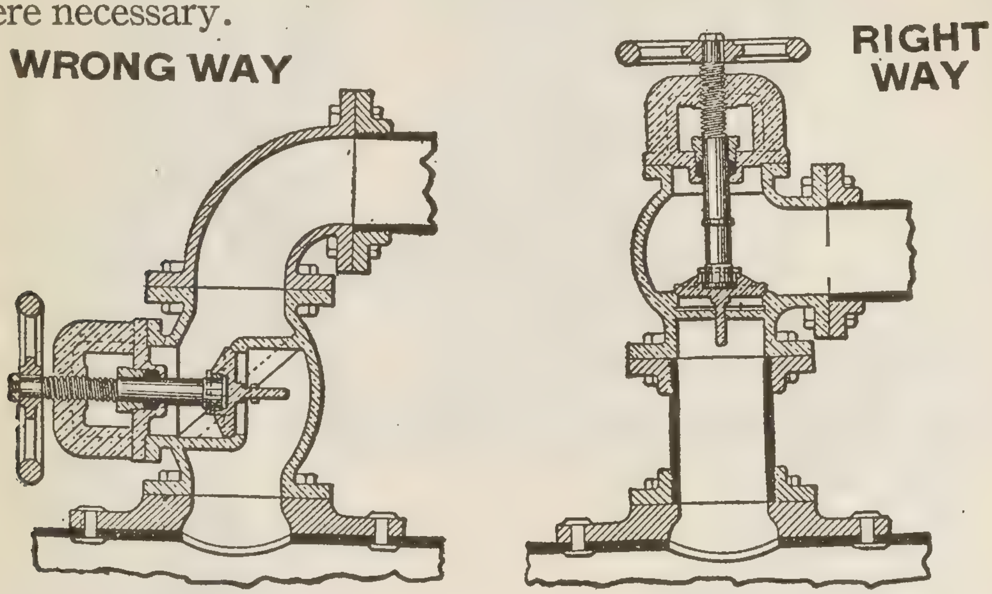
SIDE VIEW SHOWING INNER UPFLOWS, FEED WATER HEATER COILS, ETC.



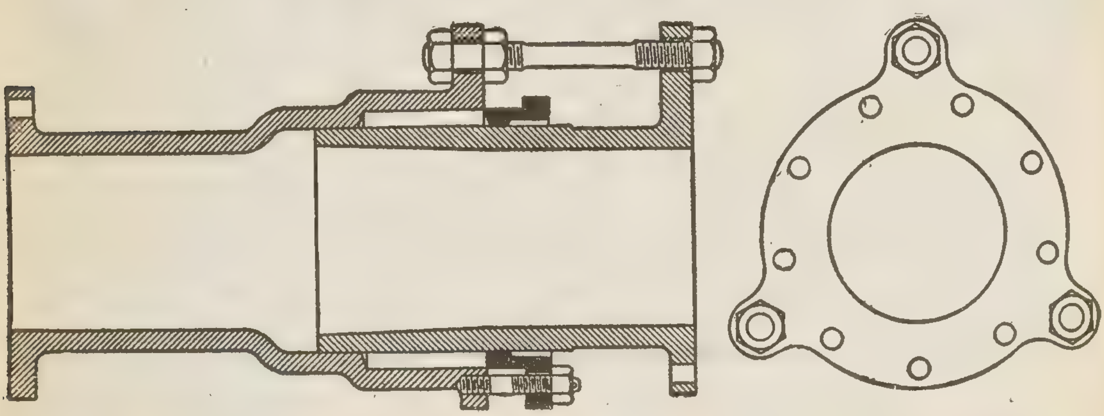
SIDE VIEW SHOWING OUTER UPFLOWS, SUPERHEATER, FEED WATER HEATER COILS, DRUM CONNECTIONS AND SUPPORTING LEGS

FIGS. 8,339 and 8,340.—Two side views of small sectional series pipe boiler designed by the author to furnish steam for experimental purposes; now under construction. The features of this design are ease and cheapness of construction, water grate and furnace enclosed on three sides by water heating surface. It can be made up entirely of pipe and fittings, though a lighter drum may be made by the use of a large tube with heads turned out of boiler plate and properly stayed. The sections are made up of ½-inch pipe and return bends with *r*, and *l*, elbows at the lower ends and are connected to upper heads by *r*, and *l*, nipples. There are 10 up flow sections, 8 inner sections as shown in fig. 8,339, and two side sections as shown in fig. 8,340. There are two super heater sections, one on each side (fig. 8,340). ***Proportions***: Up flows 26.6 square feet; feed water heater 13.3 square feet; super heater 7.1 square feet; total heating surface 47 square feet; total length ½-inch pipe 212 feet; grate area 1.92 square feet; ratio 1 to 24½. Grate is made of extra heavy ½-inch pipe spaced 1⅜ inches between centers. The case indicated in dotted lines is made of thin sheet iron lined with asbestos board.

the sliding type or flexible hangers must be provided. Expansion of the pipes is taken care of by such a method of support and by the provision of large radius bends or expansion joints where necessary.

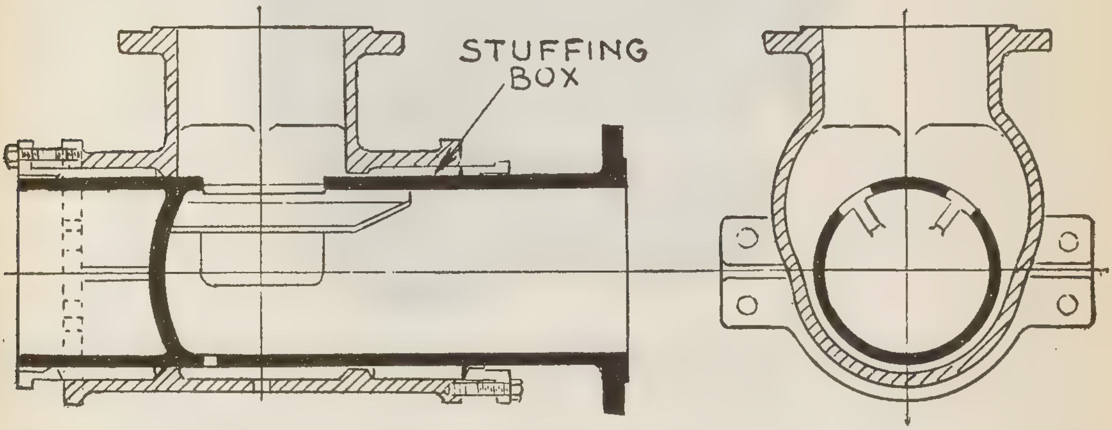


FIGS. 8,341 and 8,342.—Points on placing stop valves. The first and most important feature is to ascertain whether the valve will act as a water trap for condensed steam. Fig. 8,341 illustrates a common error in the placing of valves, as this arrangement permits an accumulation of condensed steam above the valve when closed, and should the engineer be careless and open the valve suddenly, serious results might follow owing to water hammer. Fig. 8,342 illustrates the correct method of placing the valve. It sometimes occurs, however, that it is not convenient to place the valve as shown in fig. 8,342 and that fig. 8,341 is the only manner in which the valve can be placed. In such cases, the valve should have a drain, and this drain should always be opened before the large valve is opened.

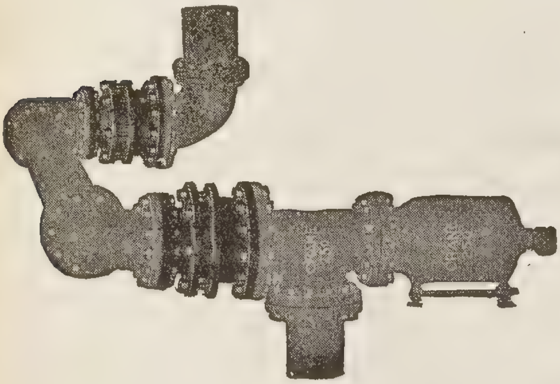


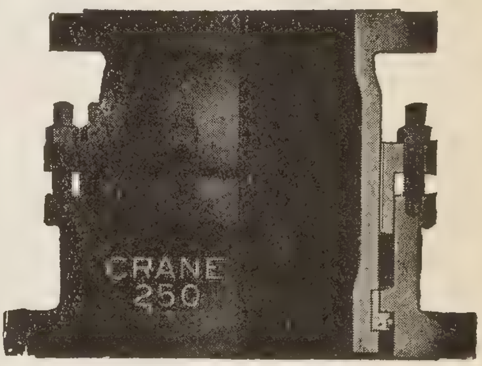
FIGS. 8,343 and 8,344.—*Ordinary* expansion joint. ***It consists of*** a recessed portion on one part of the joint into which the other fits, the enlarged part forming a stuffing box. The tie rods connecting the two flanges prevent the steam pressure forcing the two ends apart especially if it contain a bend or elbow.

If the expansion and contraction of steam pipes is not adequately provided for, stresses sufficient to cause permanent distortion of valve bodies will be thrown upon them, to the utter ruination of their finely machined or ground seat bearings, and likewise joint leaks will be much more prevalent and serious than when conditions are normal.



FIGS. 8,345 and 8,346.—***Balanced*** expansion joint used in place of an elbow. The closed end of the pipe takes the thrust, hence there is no tendency for the parts to separate. It should be noted that two stuffing boxes are required with this form of joint.





FIGS. 8,347 and 8,348.—Crane extra heavy ***swivel*** expansion joint for steam pressures up to 250 lbs. Fig. 8,347, method of placing swivel joints in a steam line; fig. 8,348, detail of joint. ***In construction,*** the male part of the joint is provided with a collar which bears against an internal ring cast on the sleeve and which prevents the two ends being forced apart by the steam pressure.

Alignment and Vibration.—While these and other elements involving constructive details are generally understood and

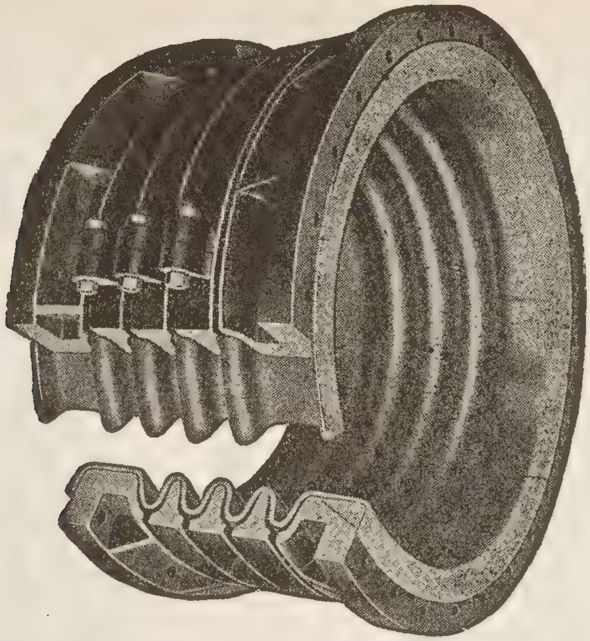
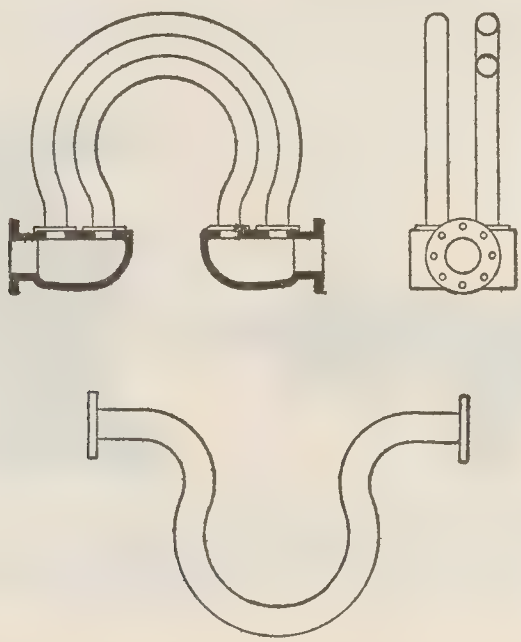
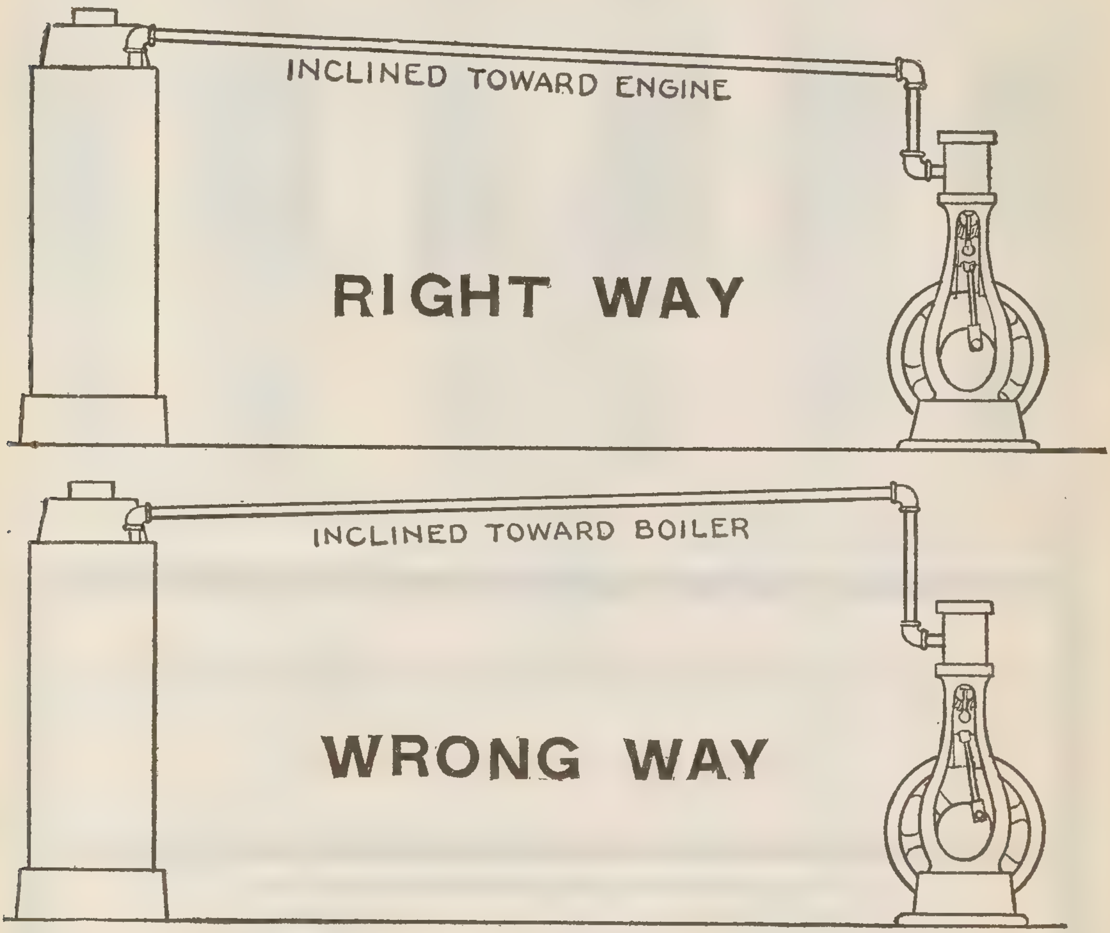


FIG. 8,349.—Badger ***corrugated*** expansion joint. ***It is made*** of corrugated copper with equalizing rings for distributing the expansion equally on all the corrugations. The equalizing rings are of cast steel, which are also to strengthen the joint.



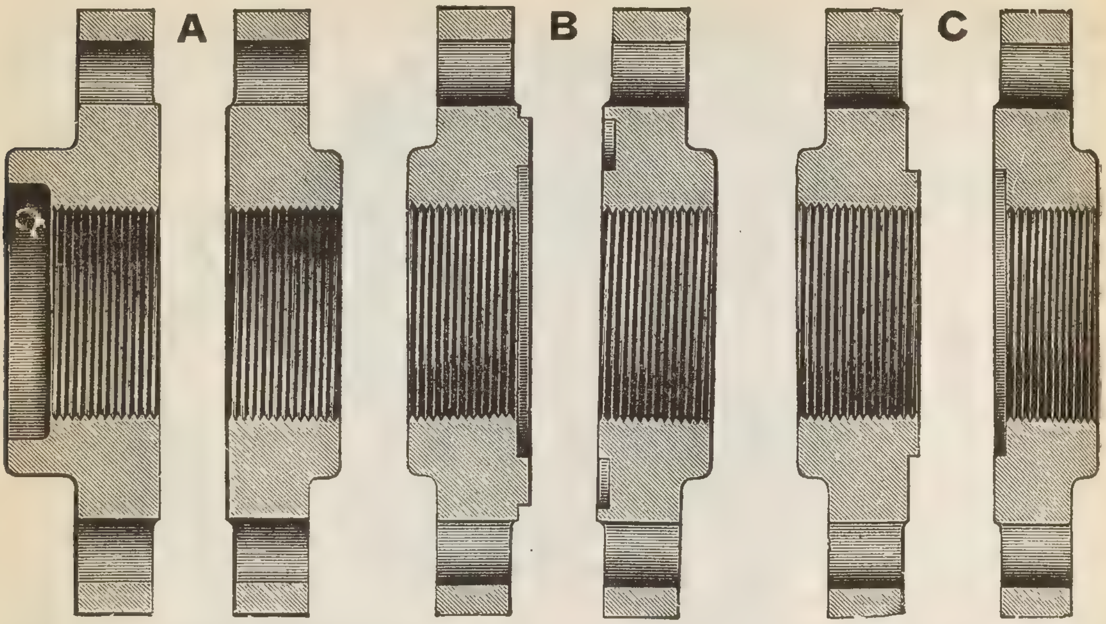
FIGS. 8,350 to 8,352.—Expansion bends. When the line is not too long and there is sufficient space, this forms a good means of providing for expansion. The figures show several pipes arranged in parallel, although one large pipe may be and is frequently used, the single pipe requiring of course a larger radius of bend than the nest of small pipes.

provided for in practice, there are instances where they are not given the attention they should receive, to the detriment of valves, fittings, and joints in the piping system. Correct align-



FIGS. 8,353 and 8,354.—Right and wrong way to pitch main steam pipe between boiler and engine. *The pipe should always be pitched to draw toward engine* as in fig. 8,353, otherwise the condensate tending to return to boiler, as in fig. 8,354, is opposed by the flow of steam in the opposite direction, resulting in the accumulation of considerable condensate in the pipe, all of which, on a sudden demand for steam, may be forced into the cylinder as a solid slug of water with probably disastrous results.

ment involves careful workmanship in the preparation and erection of the various units, to the end that they match up properly without pulling them together by means of unions or flange bolts. Vibration tendencies are controlled by suitable supports and braces which will prevent lateral movements and



Figs. 8,355 to 8,360.—Three styles of flange connections. At **A**, the two smooth faces are brought together and bolted; at **B**, a circular lug fits into a circular channel, insuring tight joint; at **C**, the ends are cut so that one fits into the other.

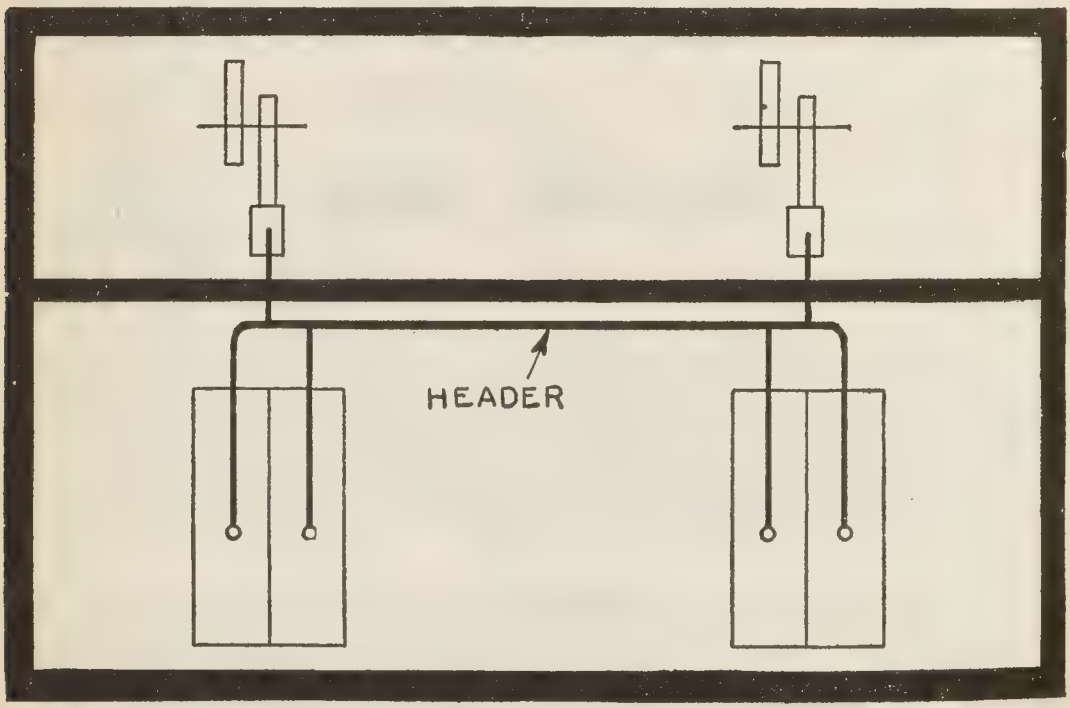


Fig. 8,361.—***Header*** system of piping. The header receives the boiler branches and the outlet to engines is from the middle, the header should increase in size from the ends at each branch connection to boiler, but for a very variable load it may at small additional expense be made same size throughout to act as a receiver.

at the same time allow the pipe sufficient freedom for lengthwise expansion and contraction.

Corrosion.—In the treatment of this element special consideration must be given to local conditions. In all cases where iron or steel pipes are exposed to moist air they should be

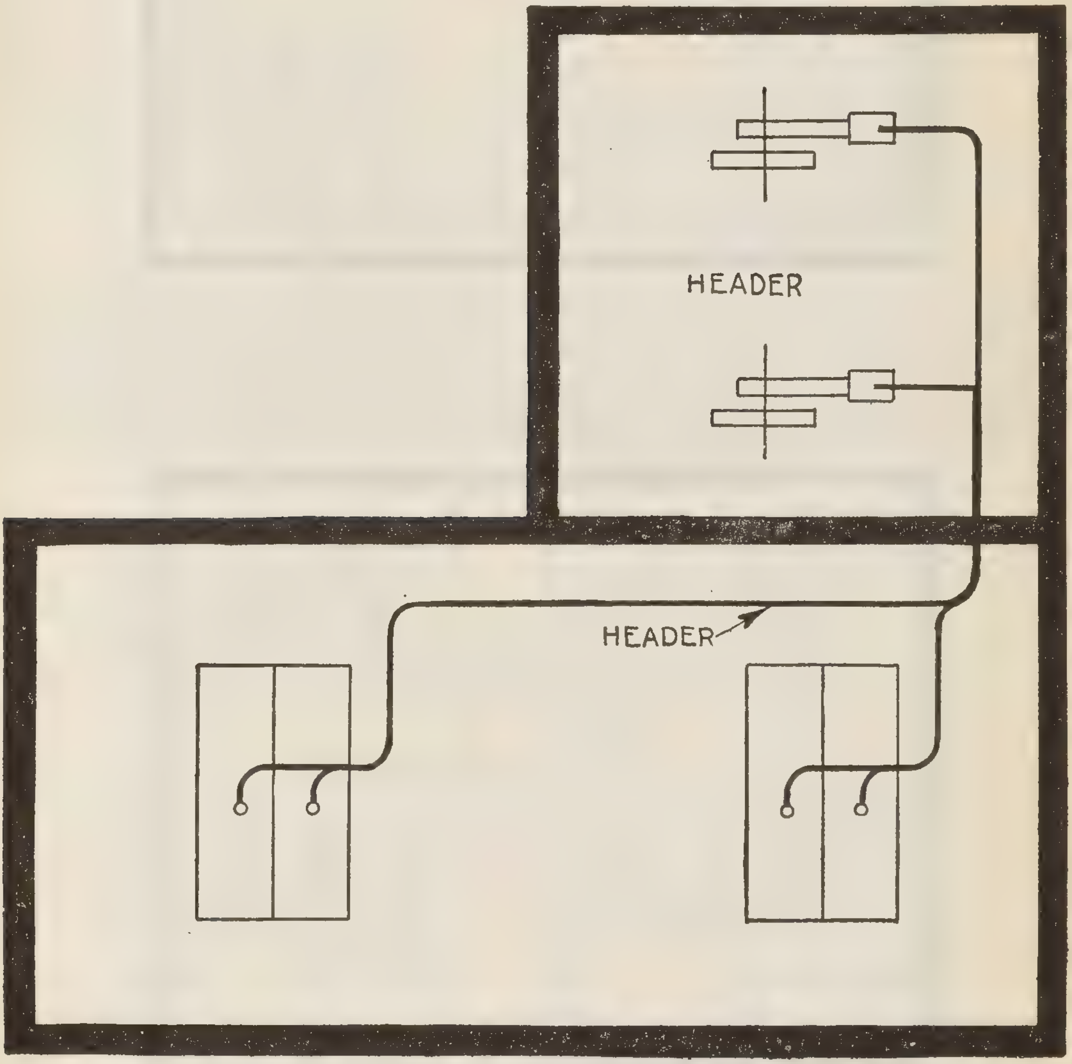


FIG. 8,362.—***Auxiliary header*** system of piping. Where boilers and engine are located as above a larger header is required than in fig. 8,361. The section farthest from the engine may be made just large enough to serve the branch connection to end boilers, and its size progressively enlarged at each branch connection. The reverse treatment may be applied to the header serving the engines, thus reducing radiation surface and cost.

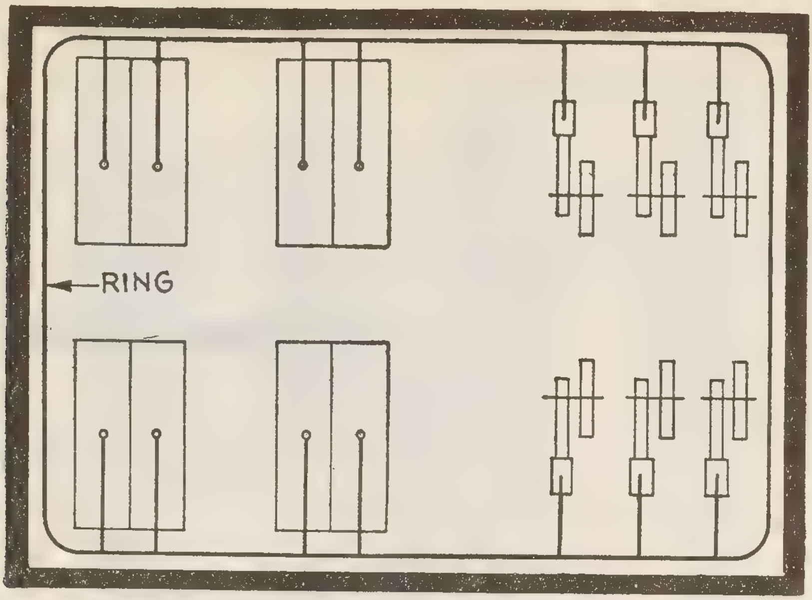


FIG. 8,363.—***Ring*** system. ***The only reason*** for installing such a system is to provide maximum insurance against complete breakdown. The system otherwise is objectionable in that it requires a multiplicity of valves, fittings, large amount of pipe, is expensive to install, and because of the large amount of radiation surface is very wasteful. With the high grade of piping materials now obtainable, the ring system is not so much in favor as formerly, and may now be considered as being extremely objectionable.

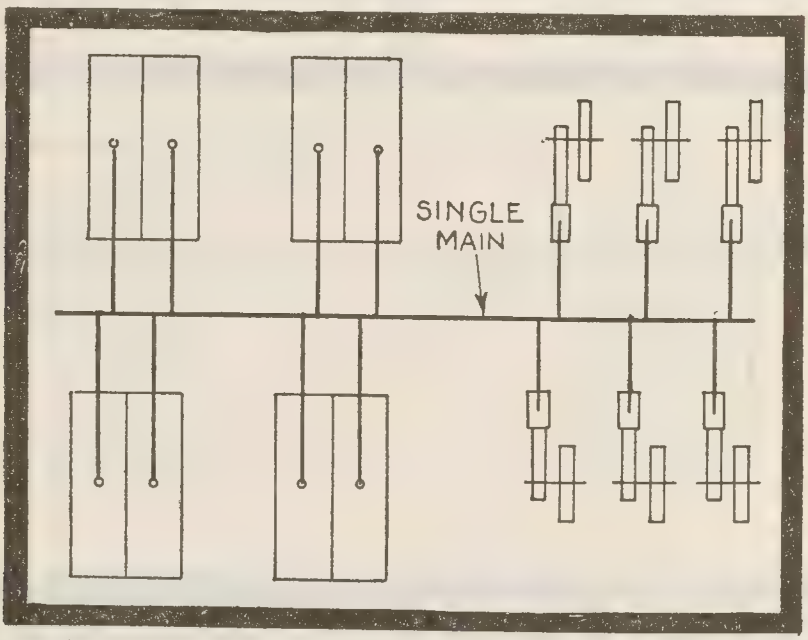
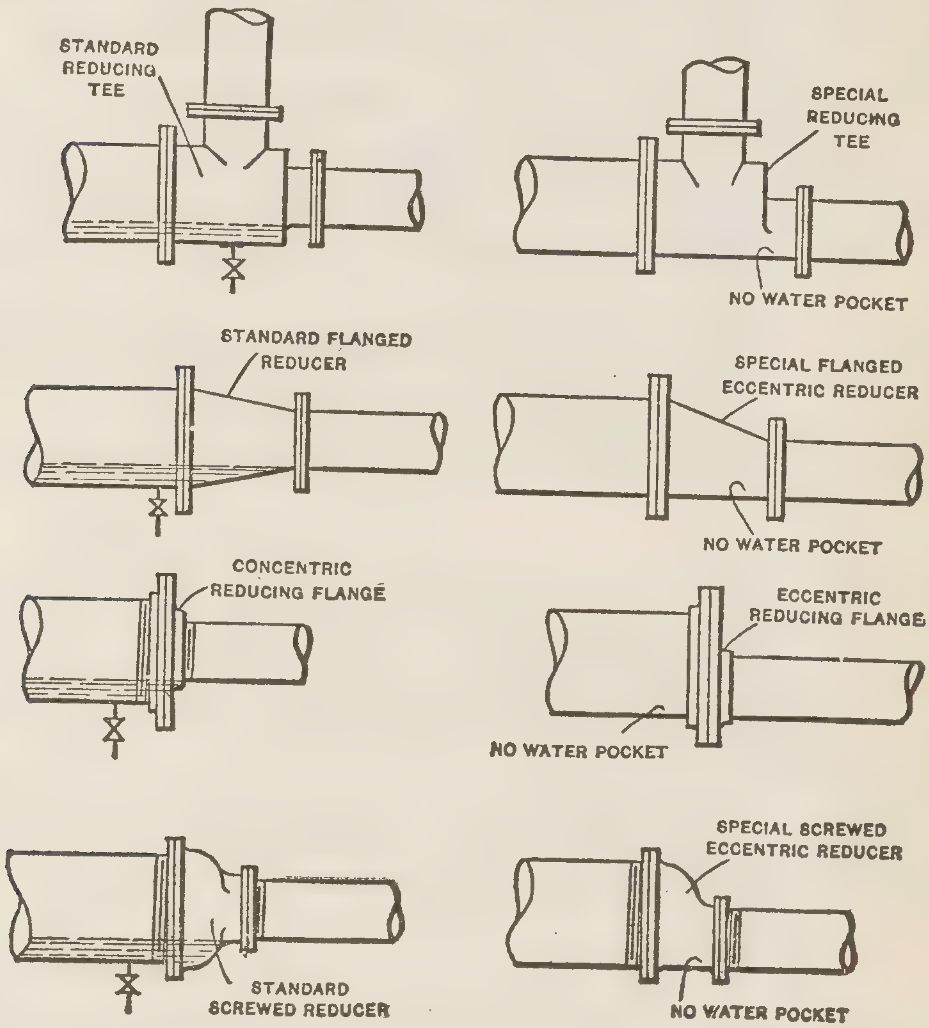


FIG. 8,364.—***Single main*** system. ***In contrast*** with the long length of pipe required for the ring system, here only a single main or header is used. This header may be conveniently suspended from the roof trusses. The arrangement as shown gives direct flow of steam from the boilers to the engines.

protected by impervious and durable coatings. Likewise, as noted under "Steam Pipe Coverings," all surfaces to be insulated should be similarly protected.

Internal corrosion is caused by solvent or oxidizing properties of water accelerated by the salts and gases dissolved in it and by the presence of air.



FIGS. 8,365 to 8,372.—Application of special fittings to avoid water pockets in pipe lines.

Hence the necessity of purifying the feed water of these harmful agents before using it in a boiler. To this end the safest plan is to consult a competent chemist experienced in the analysis and treatment of boiler feed water and follow his recommendations.

Valve Connections.—The use of screw or flange connections on valves and fittings is a question of individual judgment or preference, based upon working conditions and structural considerations. A good general rule for valves is to use flanges on sizes 2½ inches and larger for high steam pressures, 4 inches and larger for medium pressures, and 6 inches and larger for exhaust lines; smaller sizes may have screw connections.

***Calculation of Pipe Sizes.**—To efficiently convey steam or water through a pipe under pressure, the pipe must not be too small or there will be an undue drop in pressure, nor too large, in the case of a steam pipe, because of the increased condensation.

Example.—What size steam and exhaust pipes are suitable for an 8×10 engine running 250 revolutions per minute with saturated steam?

Piston speed = (10×2)×250÷12 = 416.7 ft. per minute. Area steam pipe = 50.27×416.7÷8,000 = 2.62 sq. ins. Nearest size from table (page **2,157**), 1½ in.

Numerous experiments have been made by different authorities to determine the flow of steam through pipes, and tables prepared from formulæ based on these experiments, of which the following from Babcock and Wilcox's Steam is generally accepted.

Example.—A 30 horse power engine operates on 20 pounds of steam per horse power hour. What size steam pipe should be used for a pressure drop of one pound between engine and boiler using steam at 80 pounds boiler pressure?

Total steam per minute = (30×20)÷60 = 10 pounds

Referring to the steam flow table, the two nearest values are 4.82 pounds for a 1 inch pipe and 13.3 pounds for 1½ inch pipe, accordingly a 1¼ inch pipe (not listed), nearer the correct size than either the 1, or 1½ inch size.

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*NOTE.—For steam mains of short or medium length, the usual practice has been to proportion pipes for a velocity of 8,000 feet per minute for the steam supply to engine, and 4,000 feet per minute for exhaust pipe based on cylinder displacement. These values are for saturated steam, being increased about 20 per cent for superheated steam.

Flow of Steam Through Pipes

Initial Gauge Pressure Pounds per Square Inch	Diameter† of Pipe in Inches. Length of Pipe = 240 Diameters													
	¾	1	1½	2	2½	3	4	5	6	8	10	12	15	18
	Weight of Steam per Minute, in Pounds, With One Pound Loss of Pressure													
1	1.16	2.07	5.7	10.27	15.45	25.38	46.85	77.3	115.9	211.4	341.1	502.4	804	1177
10	1.44	2.57	7.1	12.72	19.15	31.45	58.05	95.8	143.6	262.0	422.7	622.5	996	1458
20	1.70	3.02	8.3	14.94	22.49	36.94	68.20	112.6	168.7	307.8	496.5	731.3	1170	1713
30	1.91	3.40	9.4	16.84	25.35	41.63	76.84	126.9	190.1	346.8	559.5	824.1	1318	1930
40	2.10	3.74	10.3	18.51	27.87	45.77	84.49	139.5	209.0	381.3	615.3	906.0	1450	2122
50	2.27	4.04	11.2	20.01	30.13	49.48	91.34	150.8	226.0	412.2	665.0	979.5	1567	2294
60	2.43	4.32	11.9	21.38	32.19	52.87	97.60	161.1	241.5	440.5	710.6	1046.7	1675	2451
70	2.57	4.58	12.6	22.65	34.10	56.00	103.37	170.7	255.8	466.5	752.7	1108.5	1774	2596
80	2.71	4.82	13.3	23.82	35.87	58.91	108.74	179.5	269.0	490.7	791.7	1166.1	1866	2731
90	2.83	5.04	13.9	24.92	37.52	61.62	113.74	187.8	281.4	513.3	828.1	1219.8	1951	2856
100	2.95	5.25	14.5	25.96	39.07	64.18	118.47	195.6	293.1	534.6	862.6	1270.1	2032	2975
120	3.16	5.63	15.5	27.85	41.93	68.87	127.12	209.9	314.5	573.7	925.6	1363.3	2181	3193
150	3.45	6.14	17.0	30.37	45.72	75.09	138.61	228.8	343.0	625.5	1009.2	1486.5	2378	3481

* D, the density, is taken as the mean of the density at the initial and final pressures.

† Diameters up to 5 inches, inclusive, are *actual* diameters of standard pipe

Flow of Water in House Service Pipes.

According to E. Kuichling, C. E.

Condition of Discharge.	Pressure in Main, pounds per square inch.	Discharge, or Quantity capable of being delivered, in Cubic Feet per Minute, from the Pipe, under the conditions specified in the first column.								
		Nominal Diameters of Iron or Lead Service-pipe in Inches.								
		1/2	5/8	3/4	1	1 1/2	2	3	4	6
Through 35 feet of service-pipe, no back pressure.	30	1.10	1.92	3.01	6.13	16.58	33.34	88.16	173.85	444.63
	40	1.27	2.22	3.48	7.08	19.14	38.50	101.80	200.75	513.42
	50	1.42	2.48	3.89	7.92	21.40	43.04	113.82	224.44	574.02
	60	1.56	2.71	4.26	8.67	23.44	47.15	124.68	245.87	628.81
	75	1.74	3.03	4.77	9.70	26.21	52.71	139.39	274.89	703.03
	100	2.01	3.50	5.50	11.20	30.27	60.87	160.96	317.41	811.79
	130	2.29	3.99	6.28	12.77	34.51	69.40	183.52	361.91	925.58
Through 100 feet of service-pipe, no back pressure.	30	0.66	1.16	1.84	3.78	10.40	21.30	58.19	118.13	317.23
	40	0.77	1.34	2.12	4.36	12.01	24.59	67.19	136.41	366.30
	50	0.86	1.50	2.37	4.88	13.43	27.50	75.13	152.51	409.54
	60	0.94	1.65	2.60	5.34	14.71	30.12	82.30	167.06	448.63
	75	1.05	1.84	2.91	5.97	16.45	33.68	92.01	186.78	501.58
	100	1.22	2.13	3.36	6.90	18.99	38.89	106.24	215.68	579.18
	130	1.39	2.42	3.83	7.86	21.66	44.34	121.14	245.91	660.36
Through 100 feet of service-pipe, and 15 feet vertical rise.	30	0.55	0.96	1.52	3.11	8.57	17.55	47.90	97.17	260.56
	40	0.66	1.15	1.81	3.72	10.24	20.95	57.20	116.01	311.09
	50	0.75	1.31	2.06	4.24	11.67	23.87	65.18	132.20	354.49
	60	0.83	1.45	2.29	4.70	12.94	26.48	72.28	146.61	393.13
	75	0.94	1.64	2.59	5.32	14.64	29.96	81.79	165.90	444.85
	100	1.10	1.92	3.02	6.21	17.10	35.00	95.55	193.82	519.72
	130	1.26	2.20	3.48	7.14	19.66	40.23	109.82	222.75	597.31
Through 100 feet of service-pipe, and 30 feet vertical rise.	30	0.44	0.77	1.22	2.50	6.80	14.11	38.63	78.54	211.54
	40	0.55	0.97	1.53	3.15	8.68	17.79	48.68	98.98	266.59
	50	0.65	1.14	1.79	3.69	10.16	20.82	56.98	115.87	312.08
	60	0.73	1.28	2.02	4.15	11.45	23.47	64.22	130.59	351.73
	75	0.84	1.47	2.32	4.77	13.15	26.95	73.76	149.99	403.98
	100	1.00	1.74	2.75	5.65	15.58	31.93	87.38	177.67	478.55
	130	1.15	2.02	3.19	6.55	18.07	37.02	101.33	206.04	554.96

STANDARD WROUGHT PIPE

TABLE OF STANDARD DIMENSIONS

Size	Size	Diameters		Nominal Thickness	Circumference		Transverse Areas			Length of Pipe Per Sq. Foot of		Length of Pipe Containing One Cubic Foot	Nominal Weight Per Foot		Number of Threads per Inch of Screw
		External	Approximate Internal		External	Internal	External	Internal	Metal	External Surface	Internal Surface		Plain Ends	Threaded and Coupled	
Inches	Millimeters	Inches	Inches	Inches	Inches	Inches	Sq. Ins.	Sq. Ins.	Sq. Ins.	Feet	Feet	Feet			
⅛	3	.405	.269	.068	1.272	.845	.129	.057	.072	9.431	14.199	2533.775	.244	.245	27
¼	6	.540	.364	.088	1.696	1.144	.229	104	125	7.073	10.493	1383.789	.424	.425	18
⅜	10	.675	.493	.091	2.121	1.549	.358	.191	.167	5.658	7.747	754.360	.567	.568	18
½	13	.840	.622	.109	2.639	1.954	.554	.304	.250	4.547	6.141	473.906	.850	.852	14
¾	19	1.050	.824	.113	3.299	2.589	.866	.533	.333	3.637	4.635	270.034	1.130	1.134	14
1	25	1.315	1.049	.133	4.131	3.296	1.358	.864	.494	2.904	3.641	166.618	1.678	1.684	11½
1¼	32	1.660	1.380	.140	5.215	4.335	2.164	1.495	.669	2.301	2.767	96.275	2.272	2.281	11½
1½	38	1.900	1.610	.145	5.969	5.058	2.835	2.036	.799	2.010	2.372	70.733	2.717	2.731	11½
2	50	2.375	2.067	.154	7.461	6.494	4.430	3.355	1.075	1.608	1.847	42.913	3.652	3.678	11½
2½	64	2.875	2.469	.203	9.032	7.757	6.492	4.788	1.704	1.328	1.547	30.077	5.793	5.819	8
3	76	3.500	3.068	.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	19.479	7.575	7.616	8
3½	90	4.000	3.548	.226	12.566	11.146	12.566	9.886	2.680	.954	1.076	14.565	9.109	9.202	8
4	100	4.500	4.026	.237	14.137	12.648	15.904	12.730	3.174	.848	.948	11.312	10.790	10.889	8
4½	113	5.000	4.506	.247	15.708	14.156	19.635	15.947	3.688	.763	.847	9.030	12.538	12.642	8
5	125	5.563	5.047	.258	17.477	15.856	24.306	20.006	4.300	.686	.756	7.198	14.617	14.810	8
6	150	6.625	6.065	.280	20.813	19.054	34.472	28.891	5.581	.576	.629	4.984	18.974	19.185	8
7	175	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.500	.543	3.717	23.544	23.769	8
8	200	8.625	8.071	.277	27.096	25.356	58.426	51.161	7.265	442	.473	2.815	24.696	25.000	8
8	200	8.625	7.981	.322	27.096	25.073	58.426	50.027	8.399	442	.478	2.878	28.554	28.809	8
9	225	9.625	8.941	.342	30.238	28.089	72.760	62.786	9.974	.396	.427	2.294	33.907	34.188	8
10	250	10.750	10.192	.279	33.772	32.019	90.763	81.585	9.178	.355	.374	1.765	31.201	32.000	8
10	250	10.750	10.136	.307	33.772	31.843	90.763	80.691	10.072	.355	.376	1.785	34.240	35.000	8
10	250	10.750	10.020	.365	33.772	31.479	90.763	78.855	11.908	.355	.381	1.826	40.483	41.132	8
11	275	11.750	11.000	.375	36.914	34.558	108.434	95.033	13.401	.325	.347	1.515	45.557	46.247	8
12	300	12.750	12.090	.330	40.055	37.982	127.676	114.800	12.876	.299	.315	1.254	43.773	45.000	8
12	300	12.750	12.000	.375	40.055	37.699	127.676	113.097	14.579	.299	.318	1.273	49.562	50.706	8

EXTRA STRONG WROUGHT PIPE

TABLE OF STANDARD DIMENSIONS

Diameter: Nominal Internal Inches	Diameter: Nominal Internal Millimeters	Diameter: External Inches	Diameter: Approximate Internal Diameter Inches	Nominal Thickness Inches	Circumference: External Inches	Circumference: Internal Inches	Transverse Areas: External Sq. Inches	Transverse Areas: Internal Sq. Inches	Transverse Areas: Metal Sq. Inches	Length of Pipe per Square Foot of: External Surface Feet	Length of Pipe per Square Foot of: Internal Surface Feet	Length of Pipe Containing One Cubic Foot Feet	Nominal Weight per Foot Plain Ends Pounds
1/8	3	405	.215	.095	1.272	.675	.129	.036	093	9 431	17.766	3966.392	.314
1/4	6	.540	.302	.119	1.696	949	229	072	157	7.073	12.648	2010.290	.535
3/8	10	.675	423	.126	2.121	1.329	.358	141	.217	5 658	9.030	1024 689	.738
1/2	13	.840	.546	.147	2.639	1 715	554	234	.320	4.547	6 995	615.017	1.087
3/4	19	1.050	.742	.154	3.299	2.331	866	433	433	3.637	5 147	333.016	1.473
1	25	1.315	.957	.179	4.131	3.007	1.358	719	639	2 904	3.991	200 193	2 171
1 1/4	32	1.660	1.278	.191	5.215	4.015	2 164	1.283	.881	2 301	2.988	112 256	2 996
1 1/2	38	1.900	1.500	.200	5.969	4.712	2.835	1 767	1 068	2.010	2.546	81.487	3 631
2	50	2 375	1.939	.218	7.461	6.092	4.430	2.953	1.477	1.608	1.969	48.766	5.022
2 1/2	64	2.875	2.323	.276	9 032	7.298	6.492	4 238	2.254	1.328	1.644	33 976	7 661
3	76	3.500	2.900	300	10.996	9.111	9.621	6 605	3.016	1 091	1.317	21 801	10 252
3 1/2	90	4.000	3.364	.318	12.566	10.568	12.566	8.888	3 678	.954	1 135	16.202	12.505
4	100	4.500	3.826	.337	14.137	12.020	15.904	11 497	4.407	848	.998	12.525	14 983
4 1/2	113	5.000	4.290	.355	15 708	13.477	19.635	14.455	5.180	763	890	9.962	17.611
5	125	5.563	4.813	.375	17.477	15 120	24.306	18.194	6.112	.686	.793	7.915	20 778
6	150	6.625	5.761	.432	20.813	18.099	34.472	26.067	8.405	.576	.663	5.524	28.573
7	175	7.625	6.625	.500	23.955	20.813	45.664	34.472	11.192	.500	.576	4.177	38.048
8	200	8.625	7.625	.500	27.096	23.955	58.426	45.663	12.763	.442	.500	3.154	43.388
9	225	9.625	8.625	.500	30.238	27 096	72.760	58.426	14.334	.396	.442	2.464	48.728
10	250	10.750	9.750	.500	33.772	30.631	90.763	74.662	16.101	.355	.391	1.929	54.735
11	275	11.750	10.750	.500	36.914	33.772	108.434	90.763	17.671	325	.355	1.587	60.075
12	300	12.750	11.750	.500	40.055	36.914	127.676	108.434	19.242	299	.325	1.328	65.415

DOUBLE EXTRA STRONG WROUGHT PIPE

TABLE OF STANDARD DIMENSIONS

Diameter				Nominal Thickness	Circumference		Transverse Areas			Length of Pipe per Square Foot of		Length of Pipe Containing One Cubic Foot	Nominal Weight per Foot Plain Ends
Nominal Internal	Nominal Internal	External	Approximate Internal Diameter Inches		External	Internal	External	Internal	Metal	External Surface Feet	Internal Surface Feet		
Inches	Millimeters	Inches		Inches	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches			Feet	Pounds
½	13	.840	252	294	2 639	.792	.554	050	504	4.547	15 157	2887.164	1.714
¾	19	1.050	434	308	3 299	1.363	.866	.148	718	3 637	8.801	973 404	2.440
1	25	1.315	.599	358	4 131	1 882	1.358	.282	1.076	2.904	6.376	510 998	3.659
1¼	32	1.660	896	382	5 215	2.815	2.164	.630	1.534	2 301	4.263	228 379	5.214
1½	38	1.900	1 100	400	5 969	3 456	2 835	950	1 885	2.010	3 472	151.526	6.408
2	50	2.375	1 503	436	7 461	4.722	4 430	1.774	2 656	1.608	2.541	81.162	9.029
2½	64	2 875	1 771	552	9 032	5 564	6 492	2 464	4 028	1 328	2 156	58.457	13.695
3	76	3.500	2.300	600	10 996	7 226	9 621	4.155	5 466	1 091	1.660	34 659	18.583
3½	90	4 000	2 728	636	12.566	8 570	12 566	5 845	6 721	.954	1 400	24 637	22.850
4	100	4 500	3 152	674	14.137	9 902	15 904	7 803	8 101	.848	1.211	18 454	27 541
4½	113	5 000	3 580	710	15 708	11 247	19 635	10 066	9 569	.763	1 066	14 306	32 530
5	125	5 563	4.063	750	17.477	12 764	24 306	12 966	11 340	686	940	11.107	38.552
6	150	6 625	4 897	864	20 813	15 384	34 472	18 835	15.637	.576	780	7 646	53.160
7	175	7.625	5 875	875	23 955	18.457	45 664	27 109	18.555	.500	.650	5.312	63.079
8	200	8 625	6 875	875	27.096	21.598	58.426	37.122	21.304	442	555	3.879	72.424

Note—Sizes 3½ inch and larger are made by telescoping.

STANDARD BOILER TUBES

TABLE OF STANDARD DIMENSIONS

Diameter		Nominal Thickness	Nearest B Wire Gauge	Circumference		Transverse Areas			Length of Tube per Square Foot of		Nominal Weight per Foot
External	Internal			External	Internal	External	Internal	Metal	External Surface	Internal Surface	
Inches	Inches	Inches	No.	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Pounds
1¾	1.560	.095	13	5.498	4 901	2.405	1.911	.494	2 182	2.448	1 679
2	1.810	.095	13	6.283	5 686	3.142	2 573	.569	1 909	2.110	1 932
2¼	2.060	.095	13	7.069	6.472	3 976	3 333	.643	1.697	1 854	2.186
2½	2.282	.109	12	7.854	7 169	4.909	4.090	819	1.527	1 673	2.783
2¾	2.532	109	12	8.639	7 955	5 940	5 036	904	1 388	1.508	3 074
3	2.782	.109	12	9 425	8 740	7.069	6.079	.990	1 273	1 373	3 365
3¼	3.010	.120	11	10 210	9.456	8 296	7.116	1 180	1 175	1 269	4.011
3½	3 260	.120	11	10.996	10.242	9 621	8 347	1 274	1 091	1 171	4.331
3¾	3.510	.120	11	11 781	11 027	11 045	9 677	1.368	1 018	1.088	4.652
4	3.732	.134	10	12.566	11 724	12 566	10 939	1 627	954	1 023	5.532
4½	4.232	.134	10	14.137	13 295	15 904	14 066	1 838	848	902	6.248
5	4.704	.148	9	15 708	14.778	19 635	17.379	2 256	763	.812	7.669

STANDARD BOILER TUBES—CONTINUED

TABLE OF STANDARD DIMENSIONS

Diameter		Nominal Thickness	Nearest B Wire Gauge	Circumference		Transverse Areas			Length of Tube per Square Foot of		Nominal Weight per Foot
External	Internal			External	Internal	External	Internal	Metal	External Surface	Internal Surface	
Inches	Inches	Inches	No.	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Pounds
6	5.670	.165	8	18.850	17.813	28.274	25.249	3.025	.636	.673	10.282
7	6.670	.165	8	21.991	20.954	38.485	34.942	3.543	.545	.572	12.044
8	7.670	.165	8	25.133	24.096	50.265	46.204	4.061	.477	.498	13.807
9	8.640	.180	7	28.274	27.143	63.617	58.629	4.988	.424	.442	16.955
10	9.594	.203	6	31.416	30.140	78.540	72.292	6.248	.381	.398	21.240
11	10.560	.220	5	34.558	33.175	95.033	87.582	7.451	.347	.361	25.329
12	11.542	.229	—	37.699	36.260	113.097	104.629	8.468	.318	.330	28.788
13	12.524	.238	4	40.840	39.345	132.732	123.190	9.542	.293	.304	32.439

Note.—In estimating effective steam-heating or evaporating surface of tubes, the surface in contact with air or gases of combustion, according to manner of application, as whether internal or external, is to be thus taken. For heating liquids by steam, superheating steam, or transferring heat from one liquid or one gas to another, mean surface of tubes to be computed.

Boiler Tubes to conform to the A. S. M. E. Boiler Code must be so ordered.

Most boiler tubes are now made to conform to the A. S. M. E. Boiler Code, which requires that the gauge ordered is the lightest that can be furnished, so that tubes made to this specification will average heavier and of smaller internal diameter than given above.

CHAPTER 124

Heating and Ventilation

A great variety of methods have been tried for heating buildings. Many of these are more or less objectionable, and yet they are still in use. These various methods may be classified

1. With respect to the *medium* which conveys the heat, as

a. Air.
b. Water.
c Steam.
d. Electricity

2. With respect to the location of the *source* of heat, as

a. In the room to be warmed. { ***fire places***, ***stoves*** }

b. Outside of room to be warmed { ***furnaces***, ***boilers***, ***dynamos*** }

3. With respect to their efficiency and desirability, as

a. Fire places (oldest and poorest method).
b. Stoves.
c. Hot air furnaces.
d. Steam.
e. Hot water.
f. Electricity (under very special conditions).

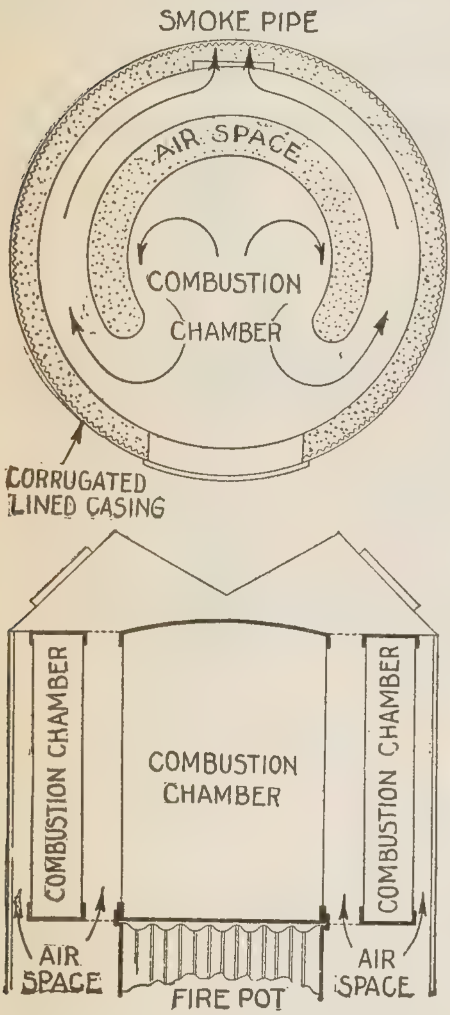
Of the various systems, steam and hot water heating are the most important.

Fire Places.—The old fashioned open fire place is the oldest and poorest method of heating. The only advantages it possesses are its action in ventilating a room, and the cheerfulness that an open fire affords. The carrying in and out of coal and ashes renders this a dirty method of heating. and one that requires frequent attention.

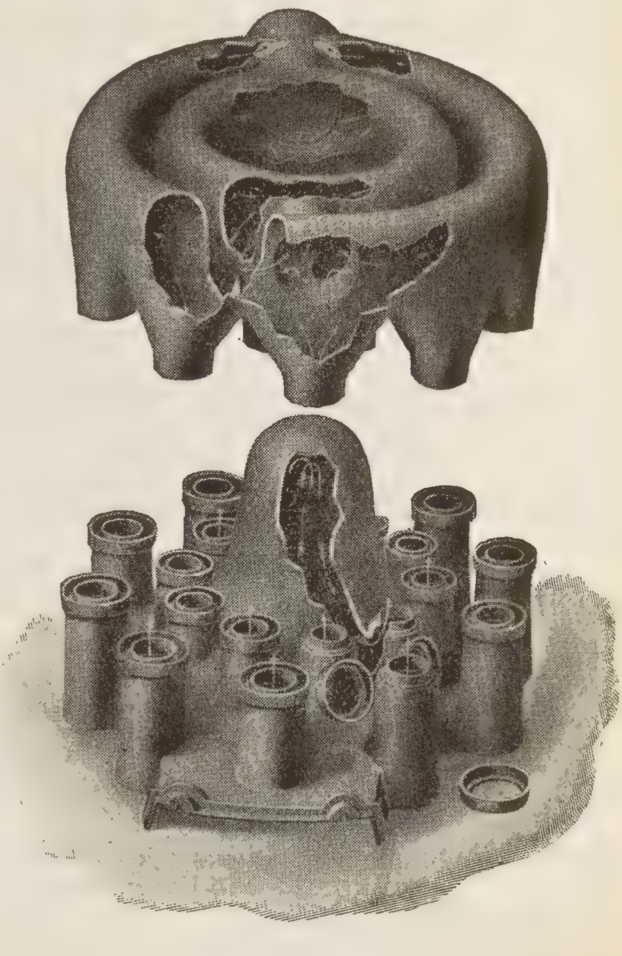
It is inadequate in cold weather and should be considered only as a supplemental form of heating for spring and fall before the weather becomes cold enough to use the regular system of heating.

Stoves.—Much more efficient is a stove than a fire place for heating a room. For a large room or small house, where one stove will furnish all the heat needed, it is the cheapest and most economical system to install, especially if conditions permit a long length of the stove pipe within the room, so as to absorb a proper amount of heat from the escaping gases.

Stoves, however, have several objections. The metal of the stove is heated to a very high temperature which robs the air of its oxygen, causing headache unless adequate ventilation be maintained; unless the dampers



FIGS. 8,373 and 8,374.—Upper construction or "radiator" of Boynton square pot hot air furnace showing relation of parts; also, travel of hot air and heated gases of combustion.



FIGS. 8,375 and 8,376.—Dome and double radiator of Mueller hot air furnace showing construction and path of gases.

be properly manipulated there is danger from the gases, especially in sleeping rooms; considerable attention is required to produce an even temperature; the handling of the coal and ashes requires considerable cleaning and dusting.

Hot Air Furnaces.—There are two methods of heating by hot air furnaces:

1. Where all the air for heating and ventilation is taken from out doors and exhausted from the building.

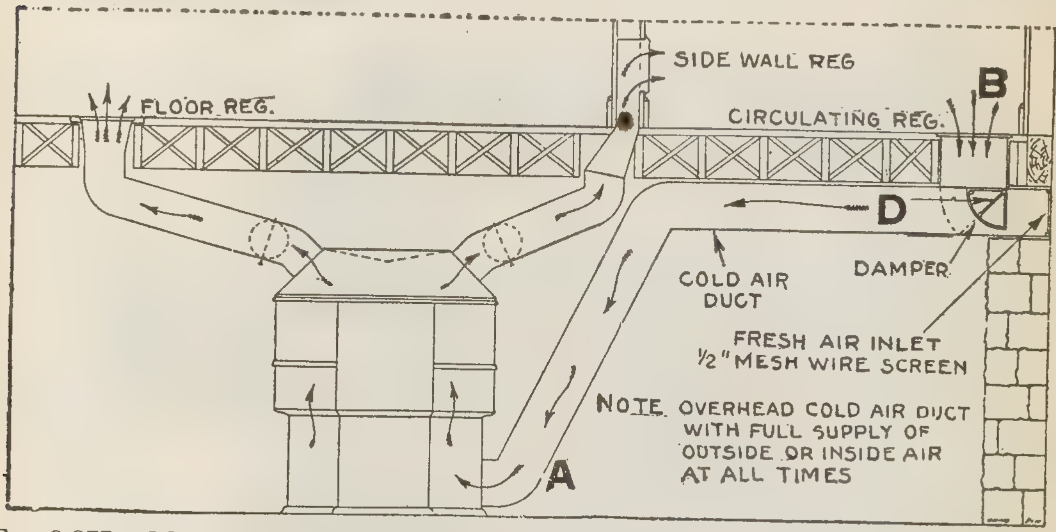


FIG. 8,377.—Method of hot air heating with outside and inside air circulation. The air to be heated enters the furnace through a duct at A. This air duct connects with a circulating register B, and is open to the outside atmosphere at C, either of which may be closed by a damper at B and C. When B, is closed all the air to be heated comes in from the outside through C, thus heating and ventilating at the same time. When C, is closed (B, open), no air is taken in from the outside, the inside air circulating between the furnace and rooms to be heated. A combination of the two methods may be obtained by placing the dampers at intermediate positions. Any hot air furnace system is objectionable and has nothing to recommend it except first cost, and this is a poor recommendation.

2. Where only the air for ventilation is taken from outdoors, and additional air is recirculated through the furnace from the building itself.

The first method which is the one generally used, is an exceedingly wasteful one, expecially in cold weather. Although it is claimed to be possible to heat a building by the second method as economically as with steam or hot water, the escaping gases through leaks in the furnace would preclude the use of this method where there is any regard for health.

Rules for Warm Air Pipes.—1. Each warm air pipe should have an upward pitch from the heater of not less than 1 inch per foot.

2. The pitch of all warm air pipes should be alike.

3. All warm air pipes in cellar or basement should be covered with sheet asbestos pipe covering. Not less than 10-lb. sheathing is recommended.

4. All warm air risers should be carried up in *inside* partitions, wherever possible.

5. In cases where it is absolutely necessary to carry up warm air risers in outer walls, such risers should be so thoroughly protected as to be *completely insulated*.

6. A separate compartment should be made in the crown or bonnet of the surface for each extra long or winding air pipe, thus insuring a positive supply of warm air to that pipe.

7. *Never use smaller than eight inch pipe*.

8. When warm air pipes are taken out of the top of the bonnet of the heater, the tops of all the elbows should be on a level, so that an equal current of air can fill all the pipes.

9. All warm air pipes should have dampers close to the heater, so the heat from them can be regulated.

10. In heating a room on the cold side of the house, or a room having a large amount of glass surface, place one register in the floor as near as possible to the furnace and place a cold air register face in the floor under or near a window and connect this cold air register by means of a separate duct to the bottom of casing, thus removing the cold air out of the room and at the same time providing a flow of warm air into the room.

Directions and Rules for Cold Air Supply.—1. The cold air supply to the heater *must* be adequate.

NOTE.—As a 12-inch elbow is so much higher than an 8-inch elbow, in order to have both pipes work properly, the top of the 8-inch elbow should be as high as the top of the 12-inch. This applies to all pipes taken from the top of the heater. The same rule applies as nearly as possible where pipes are taken from the side of the bonnet.

2. Always bring in the cold air from the coldest side of the house—west, northwest or north.

3. The cold air openings into the heater should be of equal capacity to all of the warm air pipes.

4. A cold air pit under the heater should never be more than 14 ins. deep. A pier in center is desirable to support ash pit where necessary. When more than one air opening, put partition across pit.

5. In connecting cold air box with heater, it is always most desirable to make the connection in the rear of the heater, or by having a cold air pit under the heater.

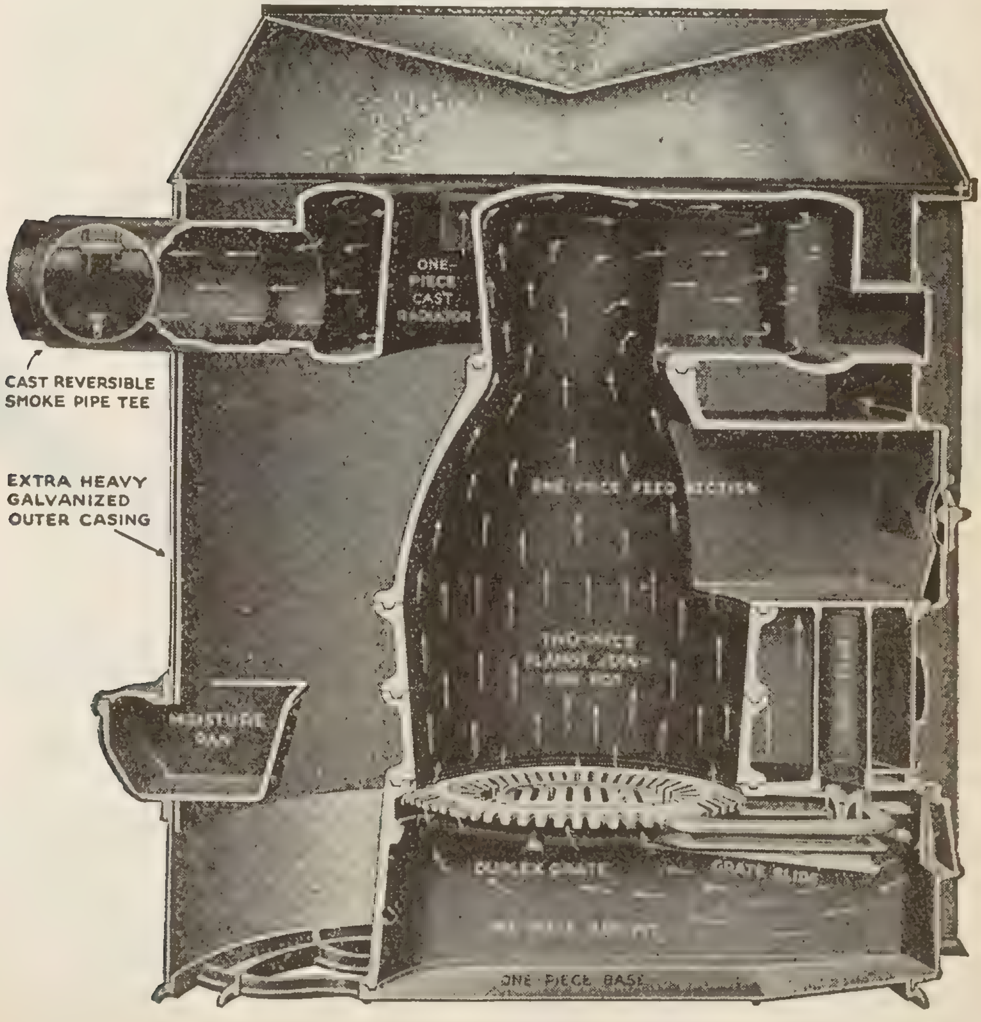


FIG. 8,378.—Favorite warm air furnace showing one piece cast iron radiator, cup joints, shaker and dumping grates, moisture pan, etc.

6. Heaters must have and will have air, and this air should be supplied from the cold air opening at the bottom of the casing. The top of any cold air opening should never be above the level of the grate.

7. The cold air box opening into casing of heater should never be higher than the total height of ash pit and should enter the heater from the rear to obtain the best results.

8. The size of cold air boxes which supply the heater when taken from a main hall or other room down to the heater, should always have the full capacity of all the pipes combined.

9. All return cold air pipes larger than 12-inch should enter a "re-

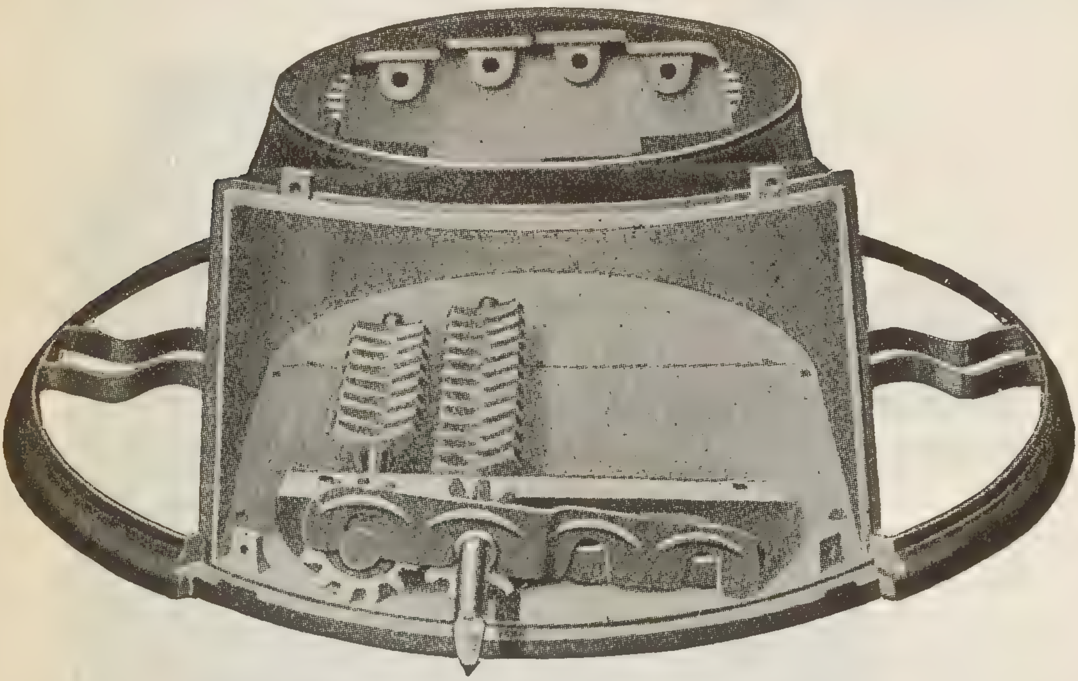


FIG. 8,379.—Vernois ash pit and base ring. The ash pit is cast in one piece and the grate bars are hung into cored pockets of the ash pit. Clinkers are either dislodged or ground up by the action of the bars in revolving when the shaker is operated.

ceiver" at the base of furnace. Pipes smaller than 12 inches may be fastened directly in the casing without the use of a "receiver."

The following table shows the proper size of furnace pipes (lower number shows size pipe for first floor, upper number size pipe for second floor) to heat rooms of various dimensions, when two sides are exposed, temperature at Register 140 degrees, Room 70 degrees. Outside zero. Rooms 8 to 17 feet in width assumed to be 9 feet high. Rooms 18 to 20 feet in width assumed to be 10 feet high. For other heights, temperatures or exposures make a suitable allowance. When first floor pipes are longer than 15 feet, use one size larger than that stated for every 15 feet.

WIDTH OF ROOM IN FEET

LENGTH OF ROOM IN FEET	8	9	10	11	12	13	14	15	16	17	18	19	20
8	8 8	8 8											
9	8 8	8 8											
10	8 8	8 8	8 8										
11	8 8	8 8	8 8	8 9									
12	8 8	8 8	8 9	8 9	8 9								
13	8 8	8 9	8 9	8 9	8 9	8 10							
14	8 9	8 9	8 9	8 9	8 10	8 10	8 10						
15	8 9	8 9	8 9	8 10	8 10	8 10	9 10	9 10					
16	8 9	8 9	8 10	8 10	8 10	9 10	9 10	9 11	9 11				
17		8 10	8 10	8 10	9 10	9 10	9 11	9 11	9 11	9 11			
18		8 10	8 10	9 10	9 10	9 11	9 11	9 11	9 11	10 12	10 12		
19			9 10	9 10	9 11	9 11	9 11	9 11	10 12	10 12	10 12	10 12	
20			9 10	9 11	9 11	9 11	9 11	10 12	10 12	10 12	10 12	11 13	11 13
21				9 11	9 11	9 11	10 12	10 12	10 12	10 12	11 13	11 13	11 13
22				9 11	9 11	10 12	10 12	10 12	10 12	10 13	11 13	11 13	11 13
23					10 12	10 12	10 12	10 12	10 13	10 13	11 13	11 13	11 13
24					10 12	10 12	10 12	10 13	10 13	10 13	11 13	11 13	11 13
25						10 12	10 13	10 13	10 13	10 13	11 13	11 13	12 14
26						10 13	10 13	10 13	10 13	11 13	11 13	12 14	12 14
27							10 13	10 13	11 13	11 13	12 14	12 14	12 14
28							10 13	11 13	11 13	11 13	12 14	12 14	12 14
29								11 13	11 13	11 13	12 14	12 14	12 14
30								11 13	11 13	12 14	12 14	12 14	12 14

USE STOCK SIZES OF PIPE

Diameter of Round Pipe	Area of Pipe Sq. In.	Diameter of Round Pipe	Area of Pipe Sq. In.
8	50	17	227
9	64	18	254
10	78	19	283
11	95	20	314
12	113	21	346
13	132	22	380
14	154	23	415
15	176	24	452
16	201		

Points on Heating Churches and other Public Buildings.—The following information as given by Homer, will be found useful especially to the contractor in estimating on installations.

1. Any building which is closed without heat for several days becomes so chilled throughout that it cannot be heated in the time taken to heat the ordinary dwelling. It should then be included in the contract that a fire be started at least *five hours* before the building is to be used, and in extremely cold weather a fire should be built in church furnaces on Saturday night that the building will be comfortable for morning services on Sunday. But, although the committee will agree to do this, the janitor may become obstinate and will not do the work, with the result that the building is not properly warmed, and the congregation will notice it and blame the furnace. This agreement with the committee should be in writing.

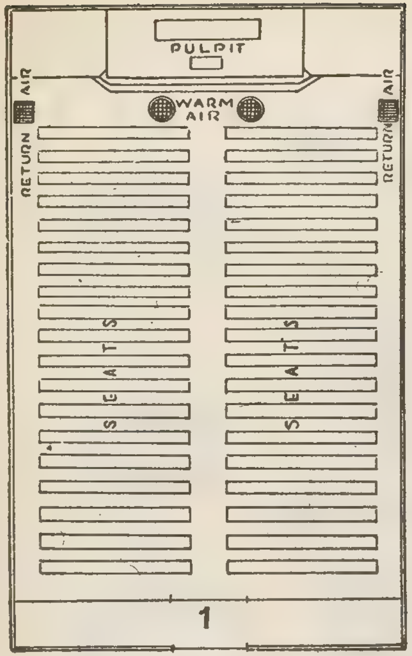
2. Remember that a furnace fired slowly will give better results than when fired to the extreme, when the circulation becomes blocked and cold air "layers" are noticed within about three or four feet from the floor. This is caused on account of the extremely heated air traveling faster than the return of cold air. Heated air has a tendency to expand, while return air is normal in its movement.

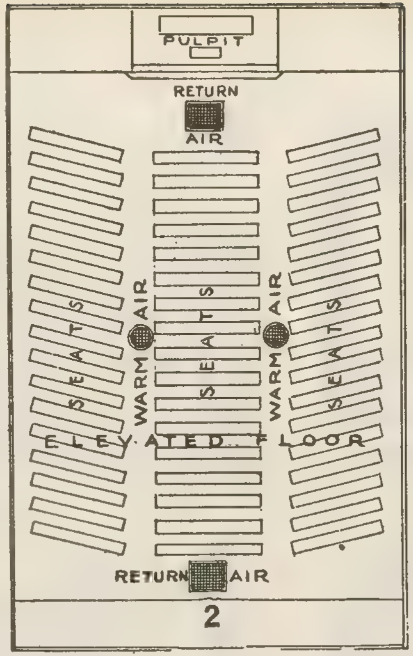
3. *Never guarantee a furnace to give satisfaction*, because you will find many people who will not be satisfied, if there be a chance of financial gain by being otherwise.

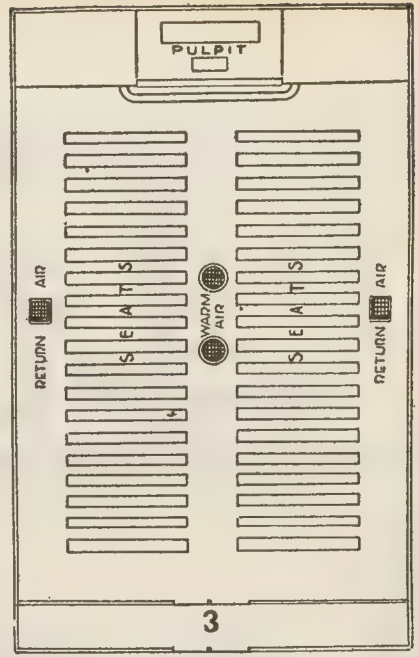
4. Don't hang a thermometer on an outside wall or casing, as it is not a fair test. The outside air is liable to leak through the windows and affect the thermometer. The wall also is sometimes penetrated by the extreme cold outside. Hang the thermometer about a foot from the outside wall and about on the level with the head.

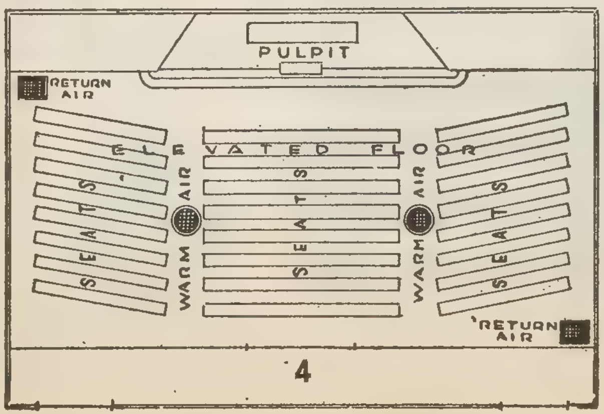
5. If the building have a balcony, which is generally about 10 feet off the floor, it will be much warmer there than on the main floor. This is natural, as heat naturally rises. It is always well to have this understood with your customers that they will not complain afterwards.

6. In figuring the capacity of a large building, *always figure to install at least one-half more heating capacity than the rating*. This makes the estimate safe because you are positive the building will be well heated. The reason for the margin above ordinary requirements is because: *a*, the building is cold all the week; *b*, there are many opinions to satisfy.

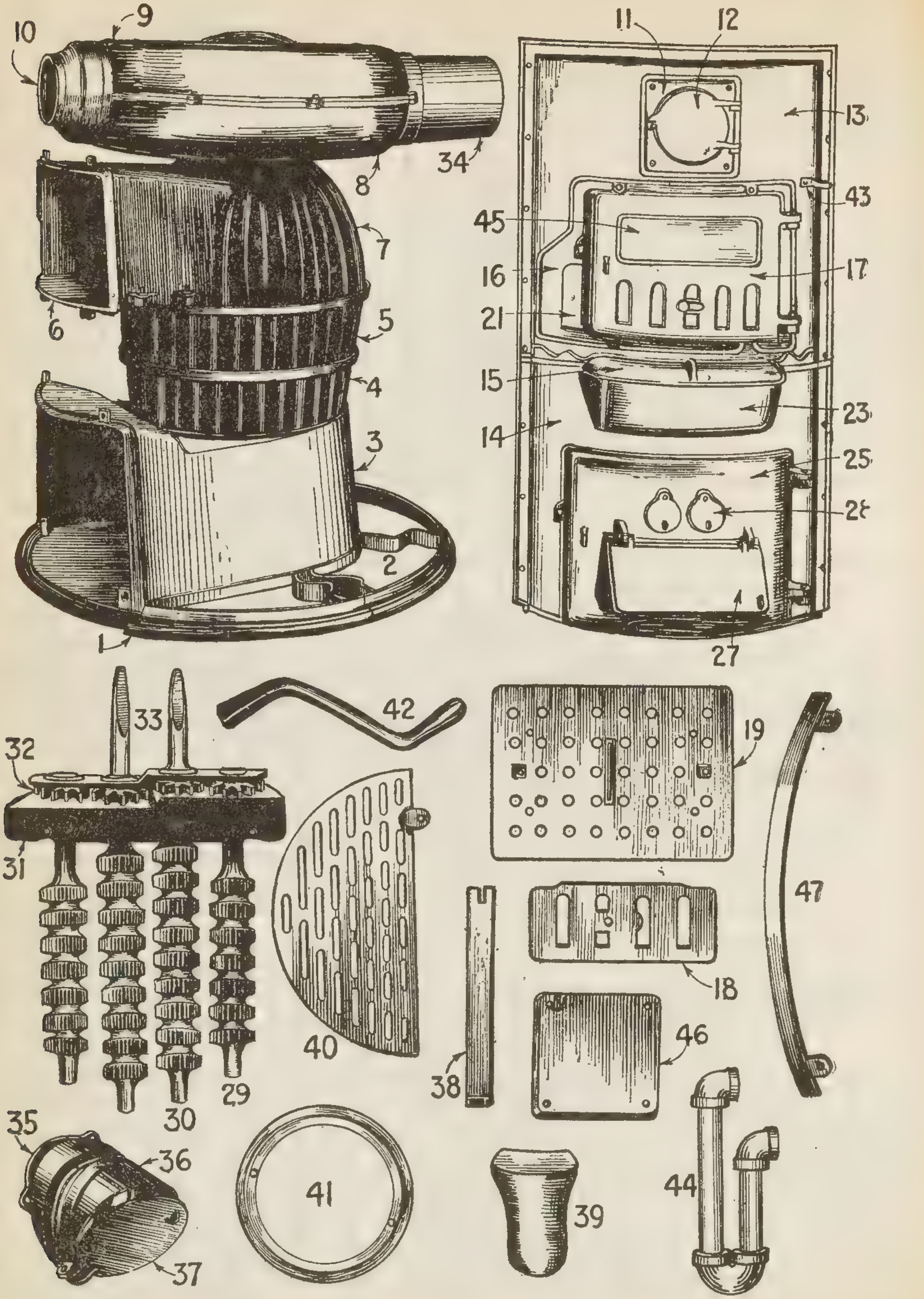








FIGS. 8,380 to 8,383.—***Church*** floor plan guides for locating warm air and cold air registers. 1, represents a church with the floor sloping to the pulpit. In this case the registers should be near the pulpit or at the lowest point in the floor. ***Cold air*** will not ascend but descends readily. 2, represents a church of the same type, except seats, with the main basement under the center of the building. Delivery of warm air is made in the center aisles and cold air is taken from opposite ends of the church. 3 represents an ordinary church with level floor and two rows of seats. Warm air is delivered in the center aisle and cold air is taken from the outside aisles. 4 represents a church of the modern type with warm air delivery in the two center aisles and the cold air taken from opposite corners of the building. Any of the above plans may be deviated from in case conditions demand a change, but great care should be taken in proper location of the registers at all times.



FIGS. 8,384 to 8,397.—Vernois furnace parts. ***The parts are:*** 1, base ring front section; 2, base ring back section; 3, ash pit; 4, lower fire pot; 5, upper fire pot; 6, dome cover; 7.

7. The high ceilings that are found in churches must be heated thoroughly before any warmth is realized on the floor where the people sit. *The best secret in church heating is to so install the heating plant that the congregation will be so "excited" over the results that you can collect the next day.* The proper thing to do in church heating is to personally superintend the firing of the furnace at its first trial.

8. Use your own judgment in quoting a price on a church heating plant. Don't be afraid that your price is too high, because, if your competitor try to install a cheap job and takes a gambling chance, the result is that he will have to remove it. If the church expect a donation, set your price, high enough to offset it.

9. Before estimating a heating plant, always look at the windows, the doors, the basement windows and walls to see that they are all tight and will not cause unnecessary drafts when the building is to be warmed on a very cold day.

10. Always note that seats or pews are not built to the floor, hindering the movement of return air to the register.

11. Another point: Nearly all churches and assembly halls have sloping floors, so that the speaker stands at the very lowest point; the furnace must be placed at this point as cold air will not ascend, but will very easily descend along an inclined floor.

Size of Pipe on Residence Work.—The size pipe required for any room depends much on conditions such as construction of building, exposure, wall and glass surface, length of warm air pipe, elevation of same, etc.

To find the pipe area for any room, the pipe must contain as much capacity in square inches as there are square feet of glass surface plus 5% of outside wall surface plus 1% of cubical contents of rooms.

FIGS. 8,384 to 8,397—*Text Continued.*

dome; 8, lower section radiator; 9, upper section radiator; 10, clean out collar; 11, clean out frame; 12, clean out door; 13, upper front; 14, lower front; 15, water pan cover; 16, fire door frame; 17, fire door; 18, fire door slide; 19, fire door lining; 21, water stop; 23, water pan; 25, ash door; 27, draft door; 28, grate stop; 29, short grate bar; 30, long grate bar; 31, grate hanger; 32, cog; 33, cog shield; 34, smoke collar; 35, lower section of check; 36, middle section of check; 37, check draft door; 38, inside casing support; 39, room heater leg; 40, wood grate; 41, expansion ring; 42, shaker handle; 43, chain guide; 44, water coil; 45, fire door panel; 46, blank panel; 47, front extension.

Example.—Room 10 feet wide, 12 feet long, 9 feet high, with two sides exposed and having three windows 2 feet 6 inches wide and 6 feet high.

Glass surface	2½ x 6 x 3	equals			45 sq. ft.
Wall	" 10	x 9	"	90	
Wall	" 12	x 9	"	108	
				198	
				45	
Less Glass surface				153	153 sq. ft.
Cubical contents 10 x 12 x 9 equals					1080 cu. ft.
One square inch for each foot of glass surface					45 sq. in.
5% of exposed wall surface					8 " "
1% of cubical contents					10 " "
				Total	63 " "

The size of pipe for above room must contain 63 sq. ins., therefore use a nine inch round pipe.

For second story rooms use same rule and deduct 15% from pipe capacity.

For rooms necessitating long runs of pipe always figure a pipe one inch larger in diameter.

To find the size furnace required to heat a residence use the rule suggested for finding the different sizes of pipes necessary to heat the rooms and the sum of the area of these pipes will determine the size furnace required.

Example.—A house having nine rooms requiring the following size pipes:

2—12 inch	equals	226	sq. in. capacity
3—10 "	"	234	" " "
2— 9 "	"	126	" " "
2— 8 "	"	100	" " "
Total capacity of pipes		686	" " "

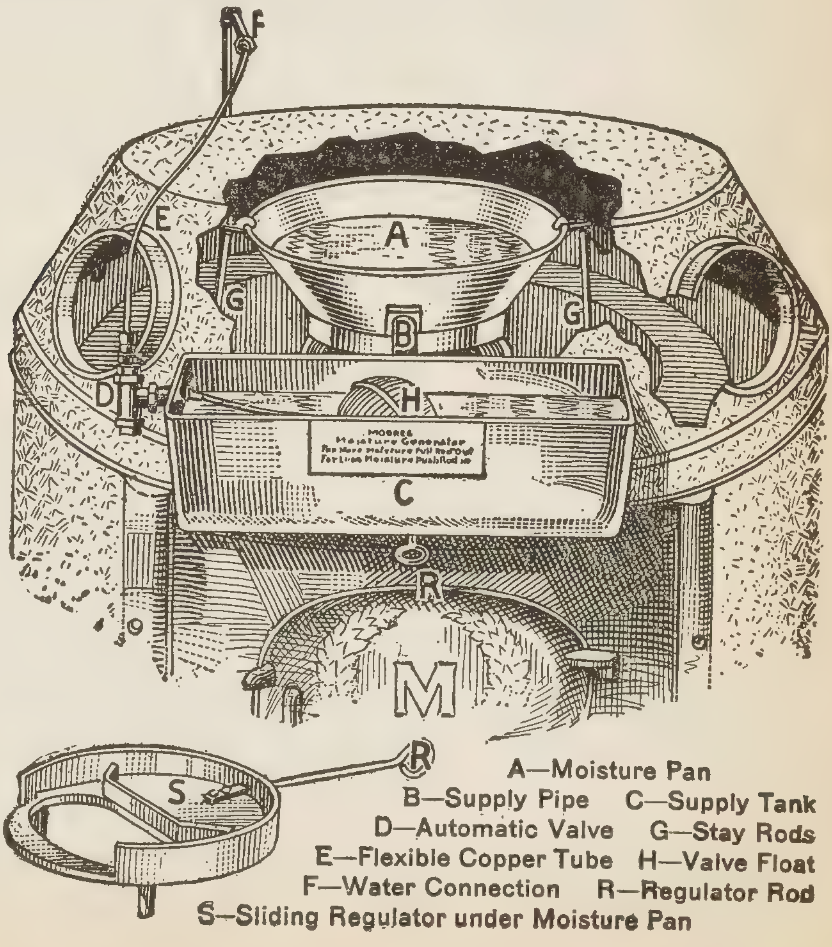
This house would require a furnace having a pipe capacity of at least 686 sq. ins.; use the furnace nearest to this in greater capacity, say 700 sq. ins.

For reference the following table will be found useful:

Pipe and Register Sizes

Diameter of round pipes	Area of pipes in sq. inches	Sizes of registers to be used with these pipes
8	50	8 x 12
9	63	10 x 12
10	78	10 x 14
12	113	12 x 15
14	154	14 x 20
16	201	18 x 20
18	254	20 x 22
20	314	22 x 24

In figuring size of registers, remember that about 60% of the area is free and 40% of the area is solid iron.



FIGS. 8,398 and 8,399.—Moore automatic moisture generator. A sliding damper with a handle extending outside the casing permits regulation of the heat to the water pan. The parts are: A, moisture pan; B, supply pipe; C, supply tank; D, automatic valve; E, flexible copper tube; F, water connection; G, stay rods; H, valve float; R, regulator rod; S, sliding regulator under moisture pan.

The following tables give pipe and register sizes, recommended by Mt. Vernon Mfg. Co.

Sizes of Pipes for First Floor When Rooms Are to Be Heated By Separate Pipes

Width of Room	Length of Room—9-foot Ceiling																						
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
8	8	8	8	8	8	9	9	10	10	10	10	10	10	10	12	12	12	12	12	14	14	14	14
9	....	8	8	8	8	9	9	10	10	10	10	10	10	10	12	12	12	12	12	14	14	14	14
10	....	....	8	8	9	9	9	10	10	10	10	10	12	12	12	12	12	12	14	14	14	14	14
11	....	....	....	9	9	9	10	10	10	10	12	12	12	12	12	12	14	14	14	14	14	16	16
12	....	....	....	....	9	10	10	10	12	12	12	12	12	14	14	14	14	14	14	14	16	16	16
13	....	....	....	....	....	10	10	12	12	12	14	14	14	14	14	14	14	14	16	16	16	16	16
14	....	....	....	....	....	....	12	12	12	12	14	14	14	14	14	16	16	16	16	16	16	16	18
15	....	....	....	....	....	....	....	12	14	14	14	14	16	16	16	16	16	16	16	16	16	18	18
16	....	....	....	....	....	....	....	....	14	14	14	14	16	16	16	16	16	16	16	18	18	18	18
17	....	....	....	....	....	....	....	....	....	14	14	14	16	16	16	16	16	16	18	18	18	18	18
18	....	....	....	....	....	....	....	....	....	....	14	16	16	16	16	16	18	18	18	18	18	20	20
19	....	....	....	....	....	....	....	....	....	....	....	16	16	16	16	18	18	18	18	18	20	20	20
20	....	....	....	....	....	....	....	....	....	....	....	....	16	16	18	18	18	18	20	20	20	20	20

Sizes of Pipes for Second Floor Rooms

Width of Room	Length of Room—9-foot Ceiling																						
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
8	8	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	10	10	10	12	12	12
9	....	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	10	10	10	12	12	12	12
10	....	....	8	8	8	9	9	9	9	9	9	10	10	10	10	10	10	12	12	12	12	12	12
11	....	....	....	8	8	9	9	9	9	9	10	10	10	12	12	12	12	12	12	12	12	14	14
12	....	....	....	....	9	9	9	9	10	10	10	10	10	12	12	12	12	12	12	12	14	14	14
13	....	....	....	....	....	9	9	10	10	10	10	10	12	12	12	12	12	14	14	14	14	14	14
14	....	....	....	....	....	....	10	10	10	10	12	12	12	12	12	14	14	14	14	14	14	14	14
15	....	....	....	....	....	....	....	10	12	12	12	12	12	12	14	14	14	14	14	14	14	14	16
16	....	....	....	....	....	....	....	....	12	12	12	12	12	14	14	14	14	14	14	14	16	16	16
17	....	....	....	....	....	....	....	....	....	12	12	12	14	14	14	14	14	14	16	16	16	16	16
18	....	....	....	....	....	....	....	....	....	....	12	14	14	14	14	14	16	16	16	16	16	16	16
19	....	....	....	....	....	....	....	....	....	....	....	14	14	14	14	16	16	16	16	16	16	16	16
20	....	....	....	....	....	....	....	....	....	....	....	....	14	14	16	16	16	16	16	16	16	18	18

The above pipe diameters are for rooms with average exposures and leader pipes of average length.

Sizes of Registers to Be Used with Warm Air Pipes

Diameter of Round Pipe	Size of Register	Diameter of Round Pipes	Size of Register
8″	8″x10″ or 10″x10″	14″	14″x16″ or 14″x18″
9″	8″x12″ or 9″x12″	16″	16″x20″ or 18″x20″
10″	10″x12″ or 10″x14″	18″	18″x24″ or 20″x20″
12″	12″x14″ or 12″x15″	20″	20″x24″ or 20″x26″

Special Rules.—For pipe heaters, it is important that no more air should be taken off the bonnet than the casing will properly supply and also that the furnace should be furnished with an amount of cold air equal to 20 per cent more than total area of warm air pipe. If both inside and outside air be used in combination, supply 110 per cent of the total area of warm air pipes with inside air and ten per cent of area with outside air.

The following table was published by the Federal Furnace League as a result of many tests of ordinary top radiator furnaces with hard coal. It is not of much value as it does not take into consideration the character of buildings nor the average outside temperature.

Size of Warm Air Pipes

Fire Pot		Casing	Total cross section area of warm air pipes	No. and size of warm air pipes that can be supplied
Diam.	Area	Diam.		
18 in.	1.8 sq. ft.	30 in.-32 in.	180 sq. in.	3- 9 in. or 4-8 in.
21 in.	2.4 sq. ft.	36 in.-40 in.	320 sq. in.	3-10 in. & 2-8 in. or 3-9 in. & 3-8 in.
24 in.	3.1 sq. ft.	40 in.-44 in.	470 sq. in.	3-10 in., 2-9 in. & 2-8 in. or 2-10 in. & 5-8 in.
27 in.	4.0 sq. ft.	44 in.-50 in.	610 sq. in.	4-10 in. & 5-9 in. or 3-10 in., 4-9 in. & 2-8 in.
29 in.	4.7 sq. ft.	52 in.-60 in.	700 sq. in.	3-12 in., 3-10 in. & 2-9 in. or 5-10 in. & 5-9 in.

Any other combination of sizes within the capacity of furnace can be used as given in the following table:

Pipe Equivalents

	8 in.	9 in.	10 in.	12 in.	14 in.	16 in.	18 in.
12 inch equals	2						
12 inch equals	1	1					
12 inch equals		2					
12 inch equals	1		1				
12 inch equals		1	1				
14 inch equals	4						
14 inch equals	2	1					
14 inch equals		3					
14 inch equals	2		1				
14 inch equals	1	1	1				
14 inch equals			2				
16 inch equals	5						
16 inch equals		4					
16 inch equals			3				
16 inch equals				2			
18 inch equals	6						
18 inch equals		5					
18 inch equals			4				
18 inch equals				3			
20 inch equals	7						
20 inch equals		6					
20 inch equals			5				
20 inch equals				3			
20 inch equals					2		
22 inch equals				4			
22 inch equals					3		
22 inch equals						2	
24 inch equals						3	
24 inch equals							2
26 inch equals						3	
26 inch equals							2
28 inch equals						4	
28 inch equals							3
30 inch equals						4	
30 inch equals							3
36 inch equals						6	
36 inch equals							4
48 inch equals						10	
48 inch equals							8

It will be noted in the table that in heating efficiency, owing to less friction, larger pipes have greater capacity relatively than smaller ones.

NOTE.—***Friction*** is the enemy of efficiency in warm air heating. It is thus advisable to have as few turns as possible in warm air pipes and to make all turns or bends with adjustable elbows or angles. Large pipes have less friction than small ones and that is why the table of pipe equivalents shows greater proportionate capacities for large pipes than small ones. Friction is produced by the contact of air with the inner surface of the pipe which retards its flow. Thus an eight inch pipe has 25 ins. of surface as compared with an area of 50 ins. or 50 per cent of the area. A nine inch pipe has 28 ins. of surface as compared with 63 ins. of area or 45 per cent. A ten inch pipe has 32 inches of surface as compared with 78 ins. of area or 40 per cent while a twelve inch pipe has 38 inches of surface as compared with 113 inches of area or 35 per cent.

So Called "Pipeless" Furnaces.—Within the past few years a new method of warm air heating has been developed into what is popularly and erroneously known as the pipeless furnace, so called because of the absence of a multiplicity of warm air pipes. This type of furnace has become quite popular and has proven very successful for the modern or open type of building.

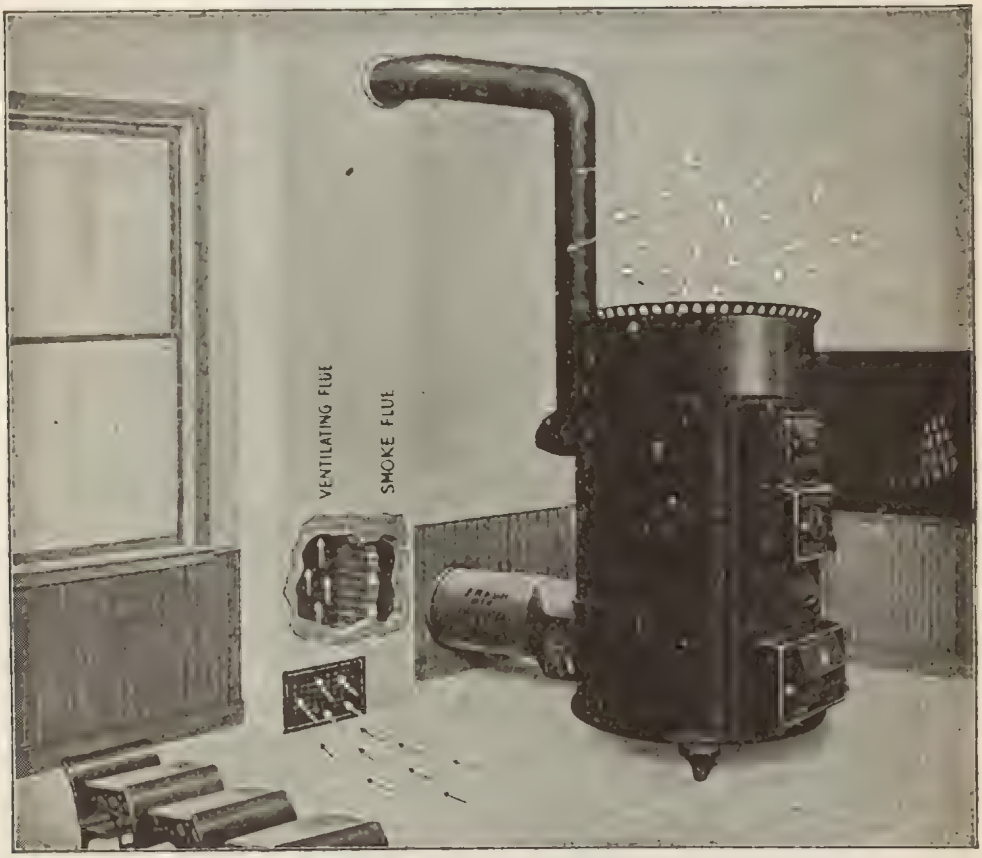


FIG. 8,400.—Favorite warm air heater; school room heating and ventilating system A.

The pipeless furnace method provides one large register only, to warm the entire suite of rooms. This register is placed directly above the furnace, and one-half of it only is used as a heat outlet. The other half of the register serves as a return or cold air supply for the furnace.

It is essential that the rooms to be heated by the pipeless method shall open into the main room, to be within range of the warm air circulation, and this indicates the limitations of the pipeless method. A room detached and cut off from the main room is not affected by the furnace, and thus it occurs that a bath room or kitchen of the bungalow is not sufficiently warm

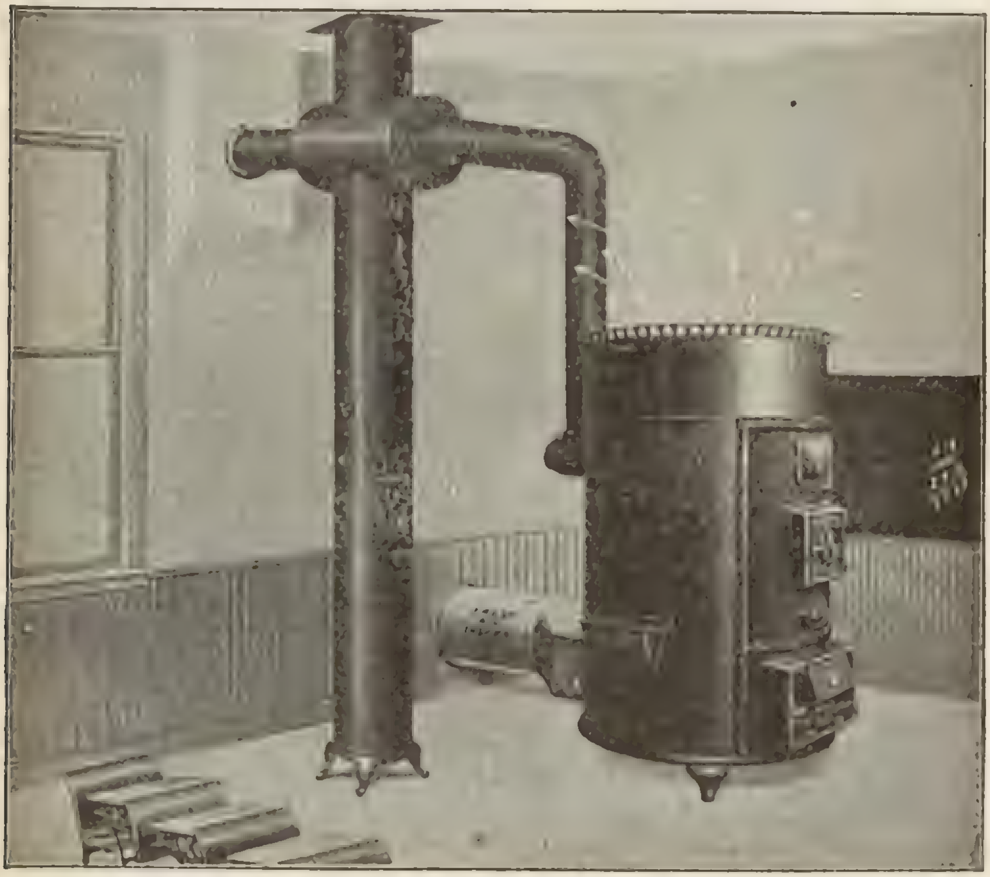


FIG. 8,401.—Favorite warm air heater; school room heating and ventilating system B.

Due to the expansion of gases with rise of temperature and consequent decrease in weight per unit volume, warm air rises and cold air descends causing a circulation.

In the operation of a pipeless furnace, as soon as a fire is built

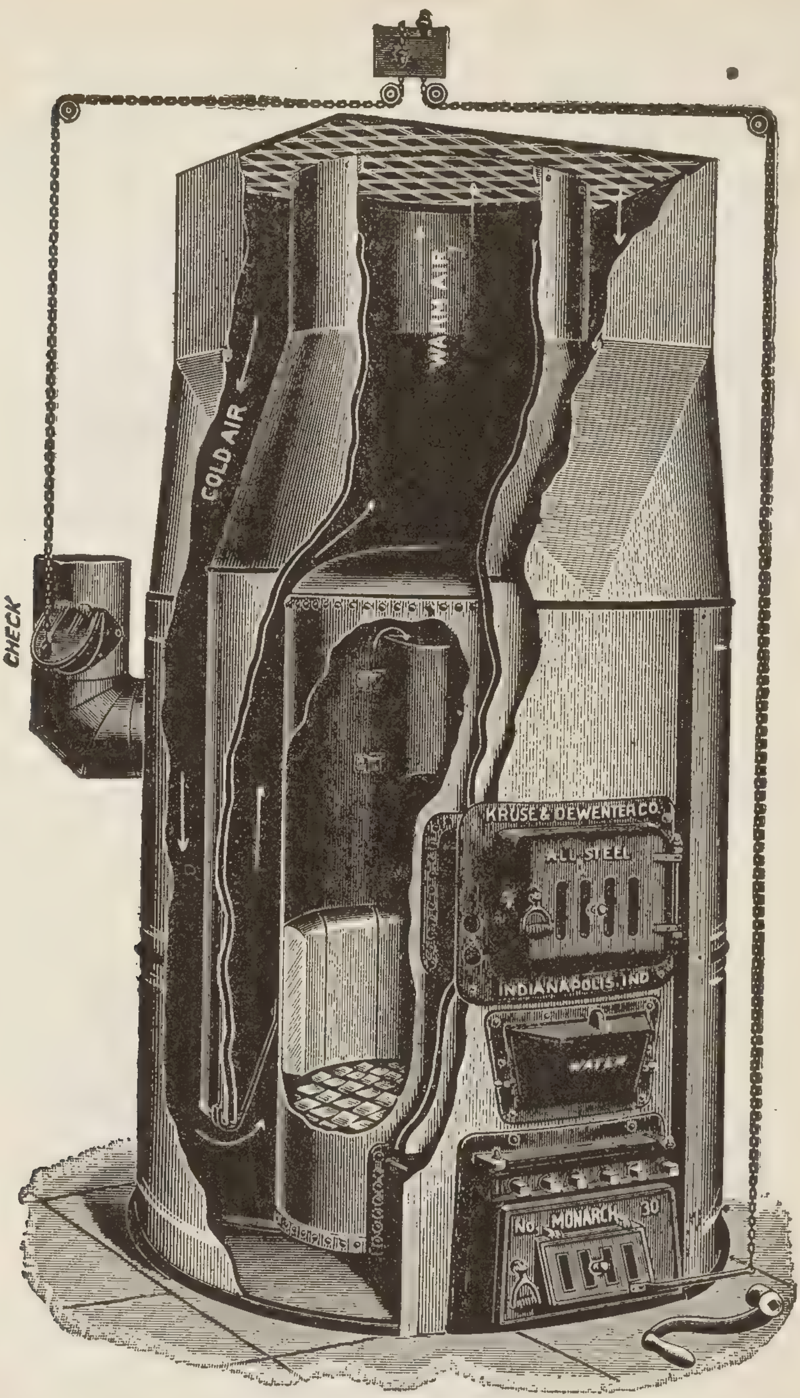


Fig. 8,402.—Kruse & Dewenter "Monarch" pipeless heater. Sectional view showing construction and course traversed by the air.

in the fire pot the air surrounding the castings becomes heated and rises and will circulate and penetrate wherever there are openings—as it becomes chilled it falls to the floor and quickly is drawn to the register, down the cold air intake, through the cold air section of the furnace casings and back to the heating zone of the furnace.

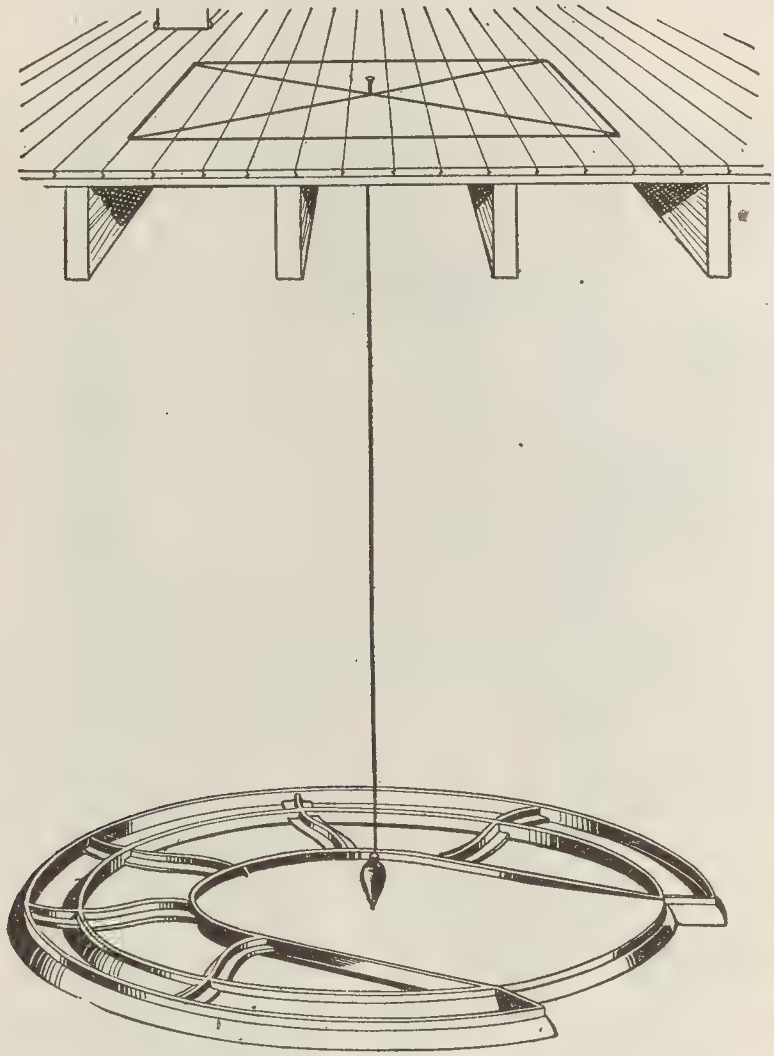


FIG. 8,403.—Directions for installing Favorite pipeless furnace 1. First, properly locate the duplex register. After this get the center of duplex register by drawing diagonal lines from the corner as shown. Drive a nail through the floor at center to which attach a plumb bob. After this attach the extension base to the main base of the furnace. Center base with the plumb bob so as to line up with the center of the register above. In doing this it will be possible to locate the register just at the desired place, because the center of the base in the basement must be underneath the center of the register.

If there be an open stairway, some heat will circulate to the upper hallway, and reach such rooms as may open into it.

For more satisfactory heating of upper rooms, ceiling registers should be provided, through which the heat will pass from the rooms below, keeping the rooms upstairs comfortable enough for sleeping purposes.

Meanwhile, as the heated air penetrates, colder air is displaced and, being heavier, descends and is constantly drawn

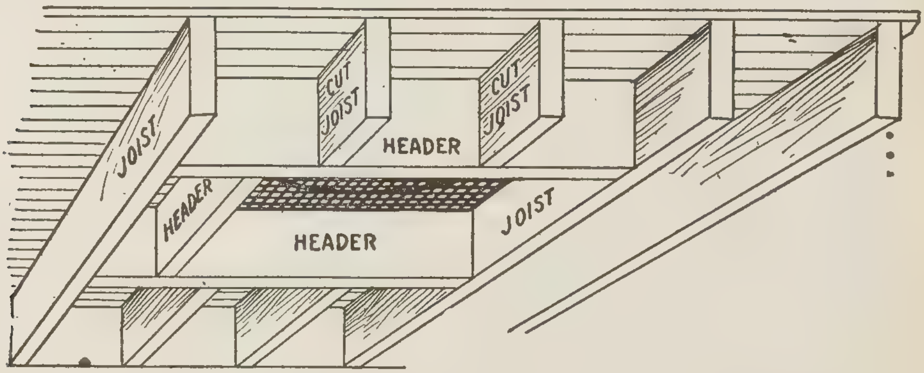


FIG. 8,404.—Directions for installing Favorite pipeless furnace 2. After locating the base and the register, then mark off the size of the register and cut the hole in the floor, putting a header across where the joists are cut to support the floor.

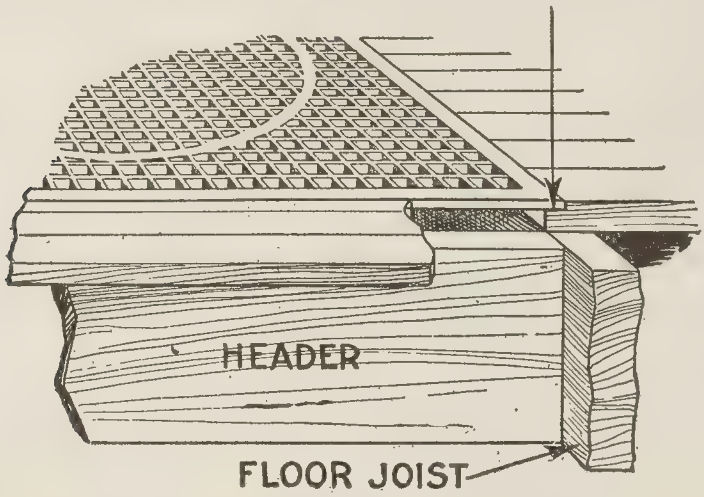


FIG. 8,405.—Directions for installing Favorite pipeless furnace 3. After cutting hole in floor (as explained in fig. 8,404). Countersink the register into the floor so as to make it flush with the floor as here shown.

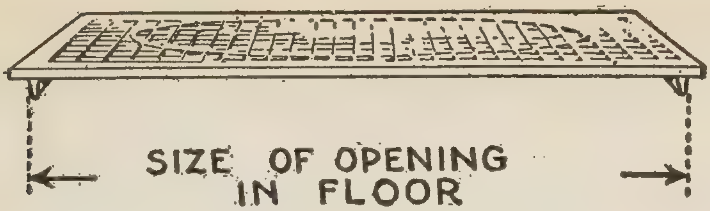


FIG. 8,406.—Directions for installing Favorite pipeless furnace 4. Sectional view of duplex register showing size of opening in floor. In setting up the furnace the first thing to do is to place the base in its proper position and to see that it is level. Then mix sand and cement and fill in around the base so as to keep any dirt or dust from sucking into the furnace at the base. Next use the furnace cement and cement the joints between the base of the furnace and the ash pit. Then cement the flange between the ash pit and lower front so as to make this air-tight, following by placing the lower front in position by bolting front to ash pit. Fill the cup joint between the ash pit and lower sections of fire pot and place the feed section in position. Then fill the cup joint between the radiator and the feed section with furnace cement and place the radiator on the furnace. Be sure the radiator is mounted so the neck of the radiator which connects the dome with the circular ring of the radiator is toward the front, in order that the heat may pass through the radiator before it goes into the smoke pipe. Follow this by cementing the flange on feed section where the upper front fits and the clean out frame on the upper front where it fits the radiator. This makes these joints gas and air tight which is necessary. Then place the upper front of the furnace in position and bolt same on. Then place the bolts that connect lower and upper cast fronts together at the joint between the lower cast front and upper cast front and bolt this in position. This mounts the cast furnace ready for placing the casing. The two wings are then placed on the cast front, temporarily. The holes are already punched in these wings.

NOTE.—Directions for installing Favorite pipeless furnace 5. The two steel casing ring supports are to be bolted on to the small open casing ring. This open casing ring is then placed around the castings and bolted temporarily to the cast front. Place the open casing ring in position and bolt it to the cast front and steel casing rings.

NOTE.—Directions for installing Favorite pipeless furnace 6. The triple inner casing, consisting of two metal sheets with asbestos between, is bolted to the cast front at the same place where the wings are bolted. This inner casing rests on the shoulder of the lower inside casing ring. This inner casing is bolted to the front with the wings by means of the same bolts and is supported by the lower casing ring which is supported by the two steel supports. This brings the triple inner casing in position. Then take the small closed casing ring and place it on the top of the inner casing which will hold the casing in position. Then cut hole in inner casing to allow for cast iron smoke pipe extension. Next place the cast extension front in position at top of front and bolt to the wings and cast front.

NOTE.—Directions for installing Favorite pipeless furnace 7. If it be desired to reverse the radiator—that is, set the radiator in such a position that the smoke pipe is not directly opposite the front, this can be accomplished by using the cast iron extension clean out which is shipped with every furnace, and cutting holes directly opposite the clean out opening in the radiator through the inner and outer casings; then attach the cast iron extension to the radiator and the clean out door on the outside of the casing to the cast extension, cementing the joints during this operation in order to insure smoke tight and gas tight fit.

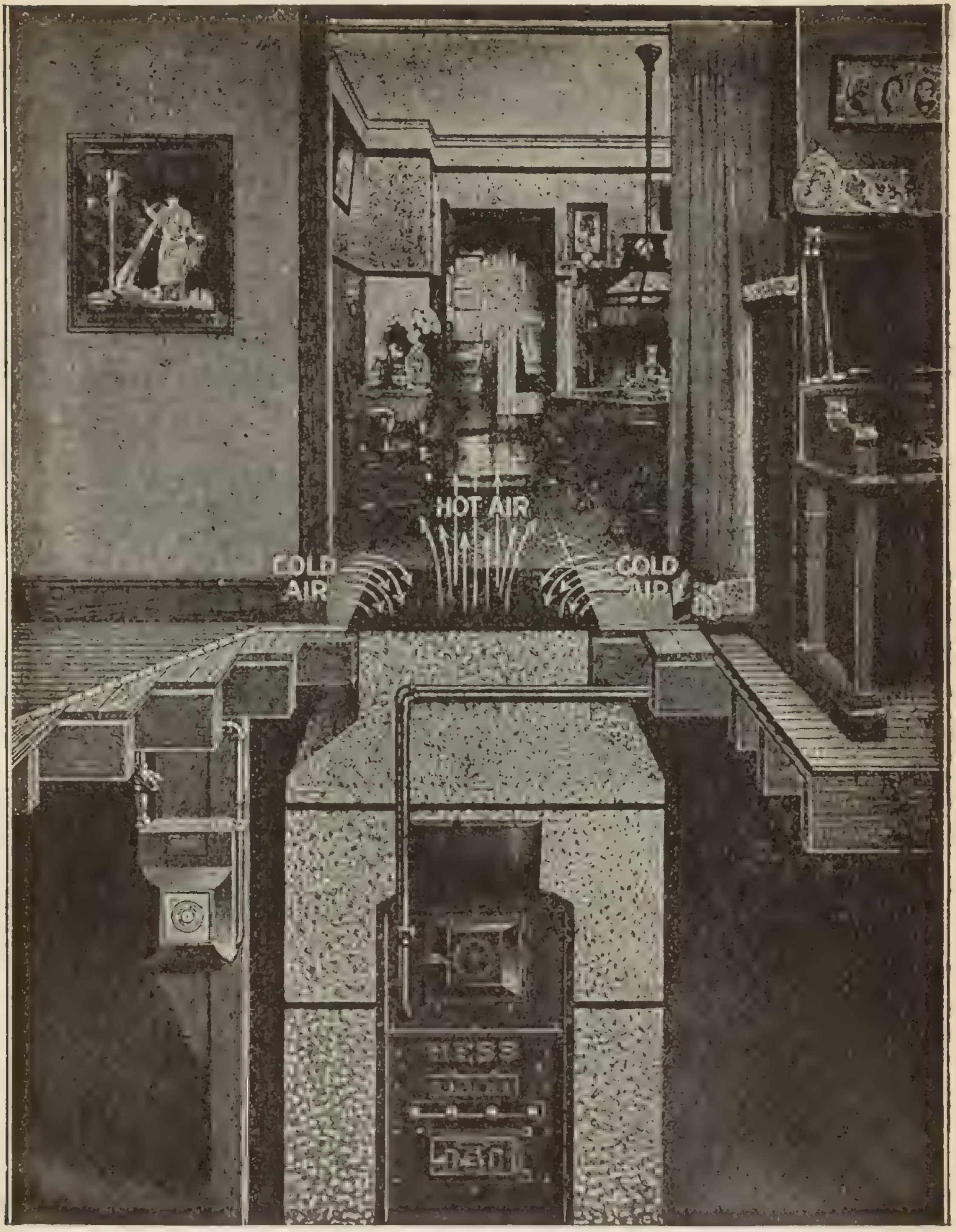


Fig. 8,407.—Hess steel pipeless furnace with hot and cold air register between two main rooms. Ceiling register to let heat into upper room, water coil for heating kitchen tank.

back into the furnace through the return air inlet surrounding the hot air pipe.

In this way a rapid and constant circulation of air is maintained, insuring uniform temperature throughout.

At first glance it might be thought that the room in which the register was placed would receive too much heat, but with the return air system of circulating, this is not so.

The method of installing a pipeless furnace is shown in fig. 8,407. Here as shown the warm air is discharged from the central portion of the register and the cold air enters through the outer portion.

NOTE.—Directions for installing Favorite pipeless furnace 8. Take the galvanized iron casing and bolt it to the outer edge of the wings. Bolt the cast casing lug in the right hand wing and place where the holes are punched to receive the bolts. Following this take the lower section of the galvanized outer casing that has the bolt holes punched in it and bolt it to the left wing; then bolt the larger half of the cast iron lug on the outside of this galvanized casing and draw same with the long draw bolt to the cast lug that has been fastened to the wing. It is necessary to place the outside casing ring in position before drawing this lower casing tight, as the casing is drawn against the lower flange of the casing ring and the flange of the extension base. After this casing has been drawn tightly it is then necessary to punch holes in the casing on the right side and bolt same permanently to the wing. Next bolt the top section of the galvanized casing to the left wing and follow instructions same as on lower casing, using the casing lugs for the purpose of drawing the casing tightly around to the wings, after which the casing is to be bolted permanently in place as described above. The top casing ring must be placed before the top casing is drawn tight. Then cut the hole in the outside galvanized casing for the cast iron smoke pipe to extend through. Cement cast iron smoke pipe extension and connect same to the radiator. You will notice the hole is cut in the casing for the moisture pan frame to be bolted to at the left hand side facing the furnace. Bolt this frame to the casing and place in moisture pan. It is necessary to fit the cast check draft that is furnished to the smoke pipe, then place the smoke pipe in position by cementing it with furnace cement to the cast smoke pipe extension. Following the above place the inner cone top bonnet in position over the top inner casing ring.

NOTE.—Directions for installing Favorite pipeless furnace 9. Place the outside galvanized bonnet in position over the inner casing ring on the outside galvanized iron casing. Next it is necessary to measure the distance between the register in the floor and the collar on the inner cone top bonnet so as to get the length of the round pipe to connect to the register. This must be cut according to the height of the basement in which the furnace is being installed. The square galvanized cold air pipe is placed on the casing in the same manner and cut according to the height of the basement. After placing the square cold air pipe in position, nail same to the floor, so as to hold it securely to the outer galvanized bonnet, then hammer the slip joint together where the square pipe fits on to the outer bonnet. The regulator that is furnished with the furnace should be attached to a door frame, studding or baseboard. Two small holes must be drilled in the floor for the chains to go through, connecting with the pulleys, then to check draft on the smoke pipe and to draft door at the front of the furnace. Then bolt the two Alaska handles—one to the feed and the other to the ash pit door and the furnace is ready for fire.

The circulation of the air from furnace through house and return is shown in fig. 8,408, which also illustrates the type of house suited for pipeless furnace heating.

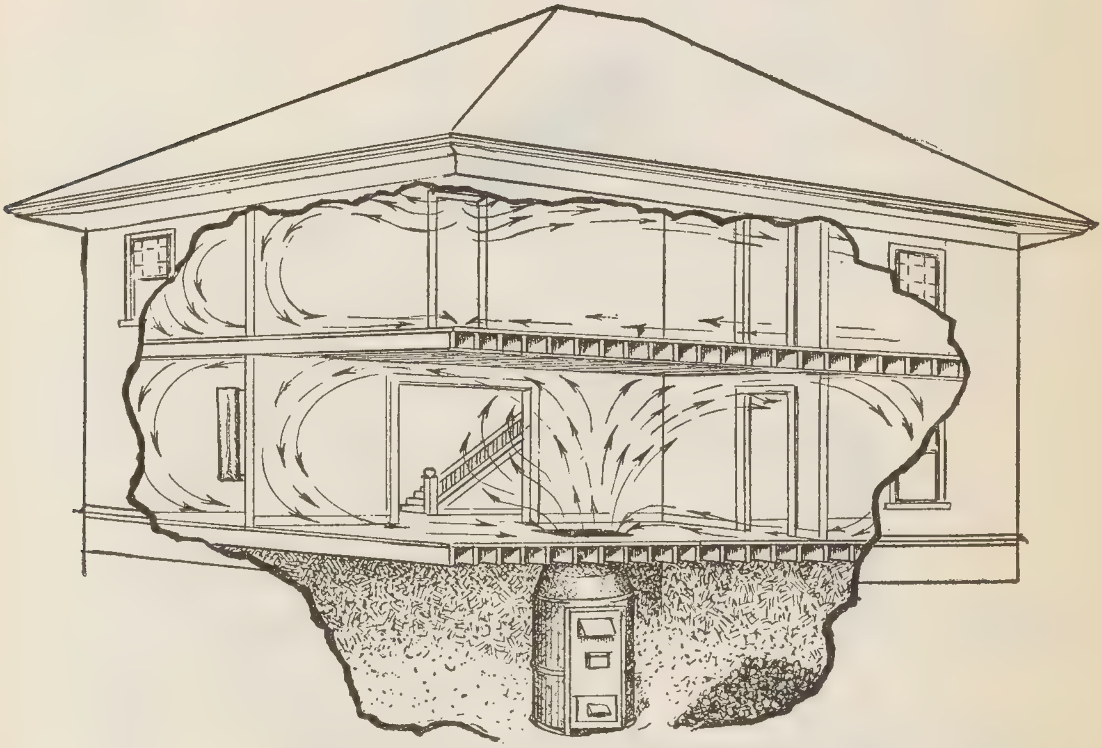


FIG. 8,408.—Small open type house heated by pipeless furnace showing circulation of the air in heating.

To heat a detached room, such as a bath room or kitchen an additional pipe may be attached, if desired. It is necessary, in such case, to divert a part of the heated air from the center pipe. For this purpose, an extra set of valves is installed, as shown in fig. 8,415 by means of which the flow of air may be divided, a part of it supplying the separate smaller pipe, the bulk of it still passing upward through the large pipe and registers.

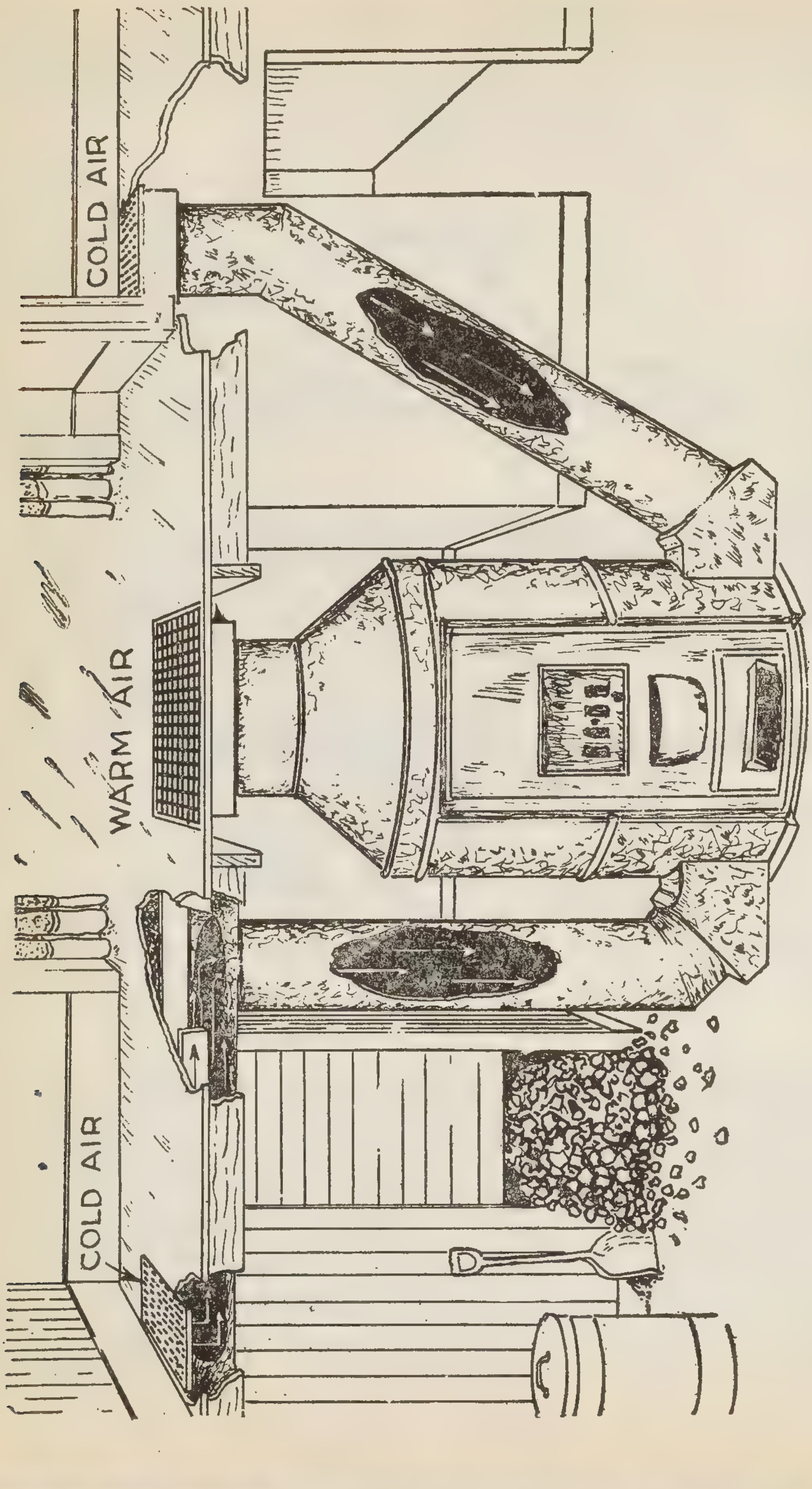


FIG. 8,409.—Pipeless furnace with separate returns for cold air. ***The warm air*** is delivered directly above the furnace through a single warm air register while the cold air can be piped from the living rooms directly to the base of the furnace. In the very lowest priced system of heating, return air can be admitted by simply cutting holes in the lower casing. This arrangement however is not recommended. The cold air should be returned from the living rooms through pipes as shown.

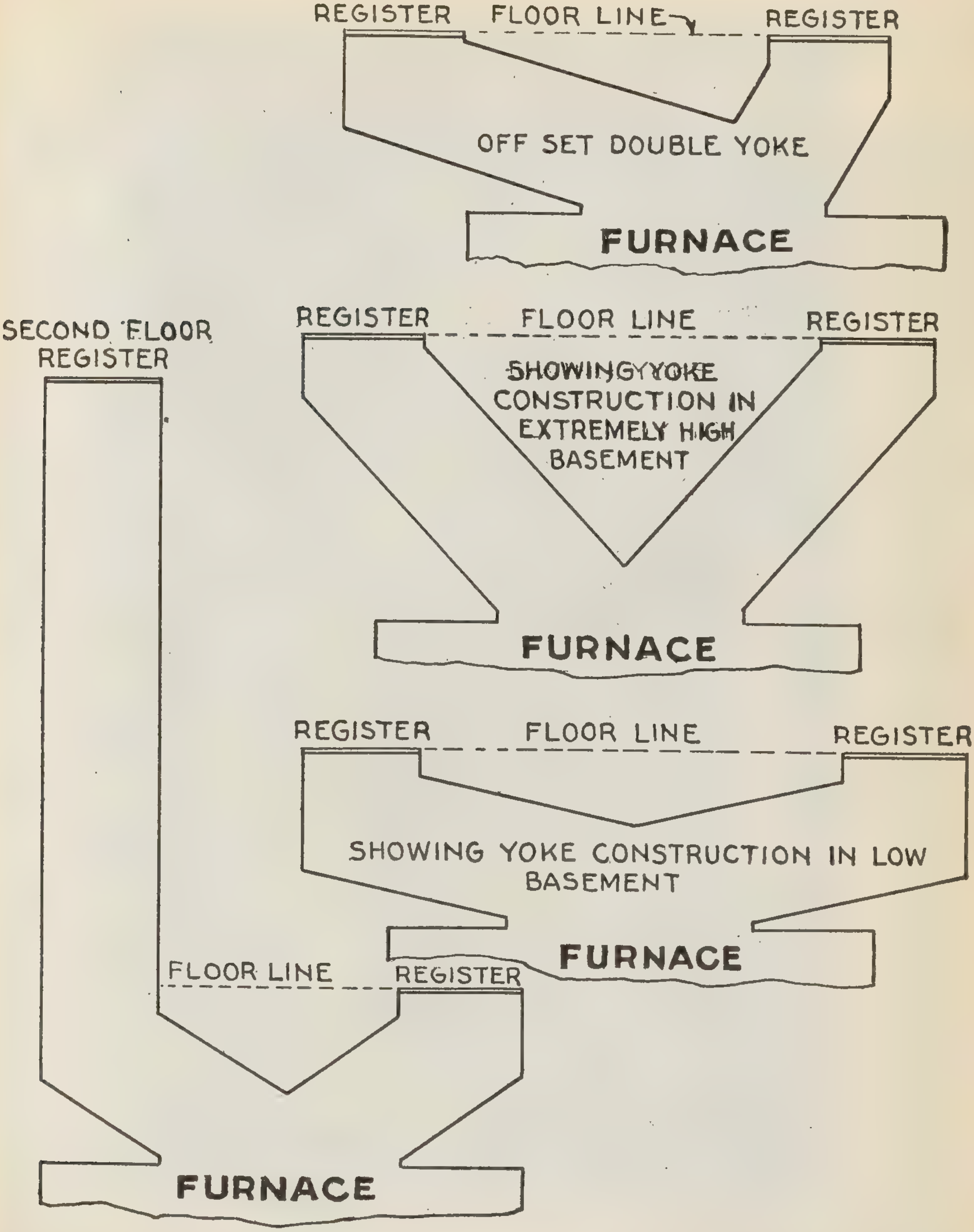


FIG. 8,410 to 8,413.—Various Homer yoke arrangements. ***It should be noted*** that the wider the spread, the higher the basement must be.

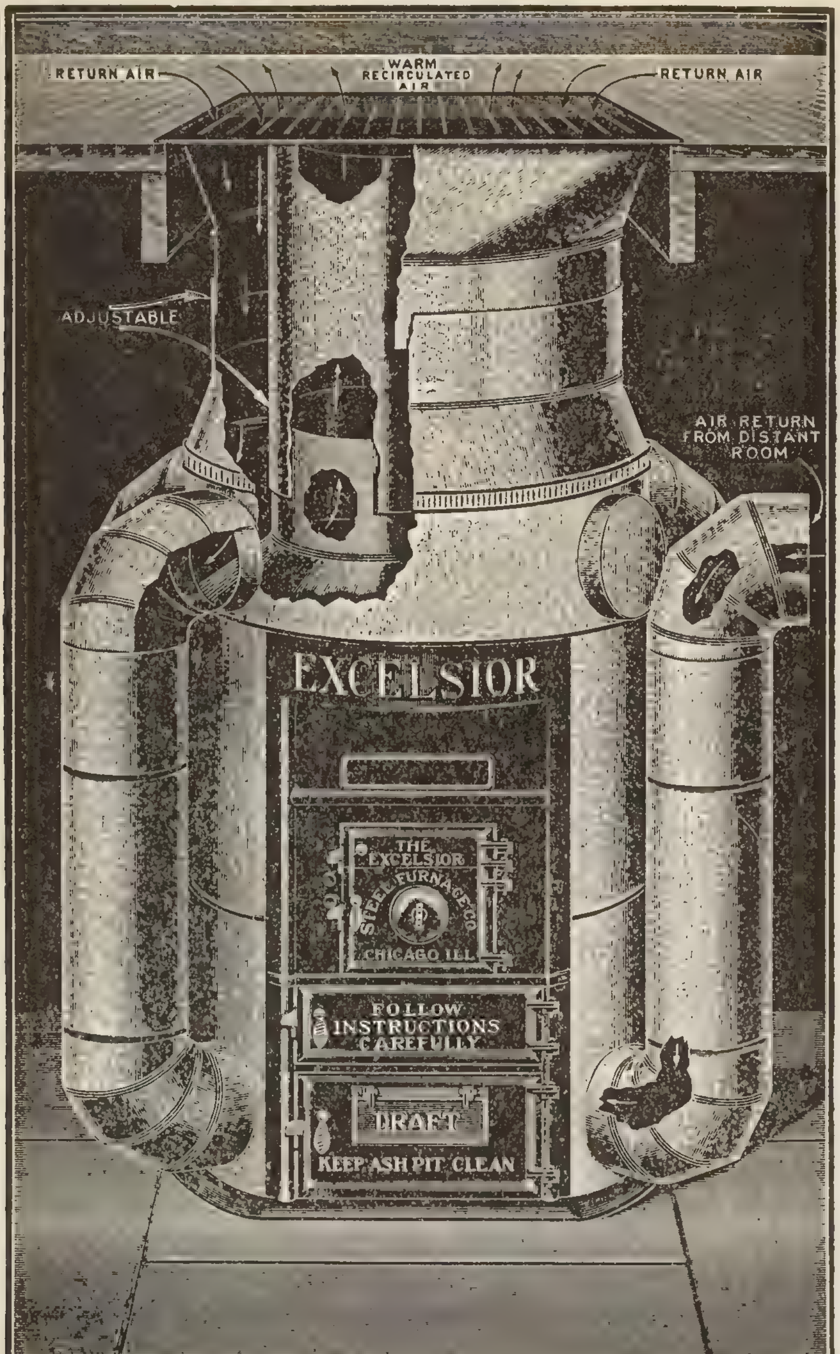


FIG. 8,414.—Excelsior pipeless furnace showing hot air and return air spaces, also air return from distant room.

This extra pipe is not recommended if the detached room be over 18 or 20 feet from the furnace. Such rooms can be heated by hot water radiators connected to a water heater placed in the fire box.

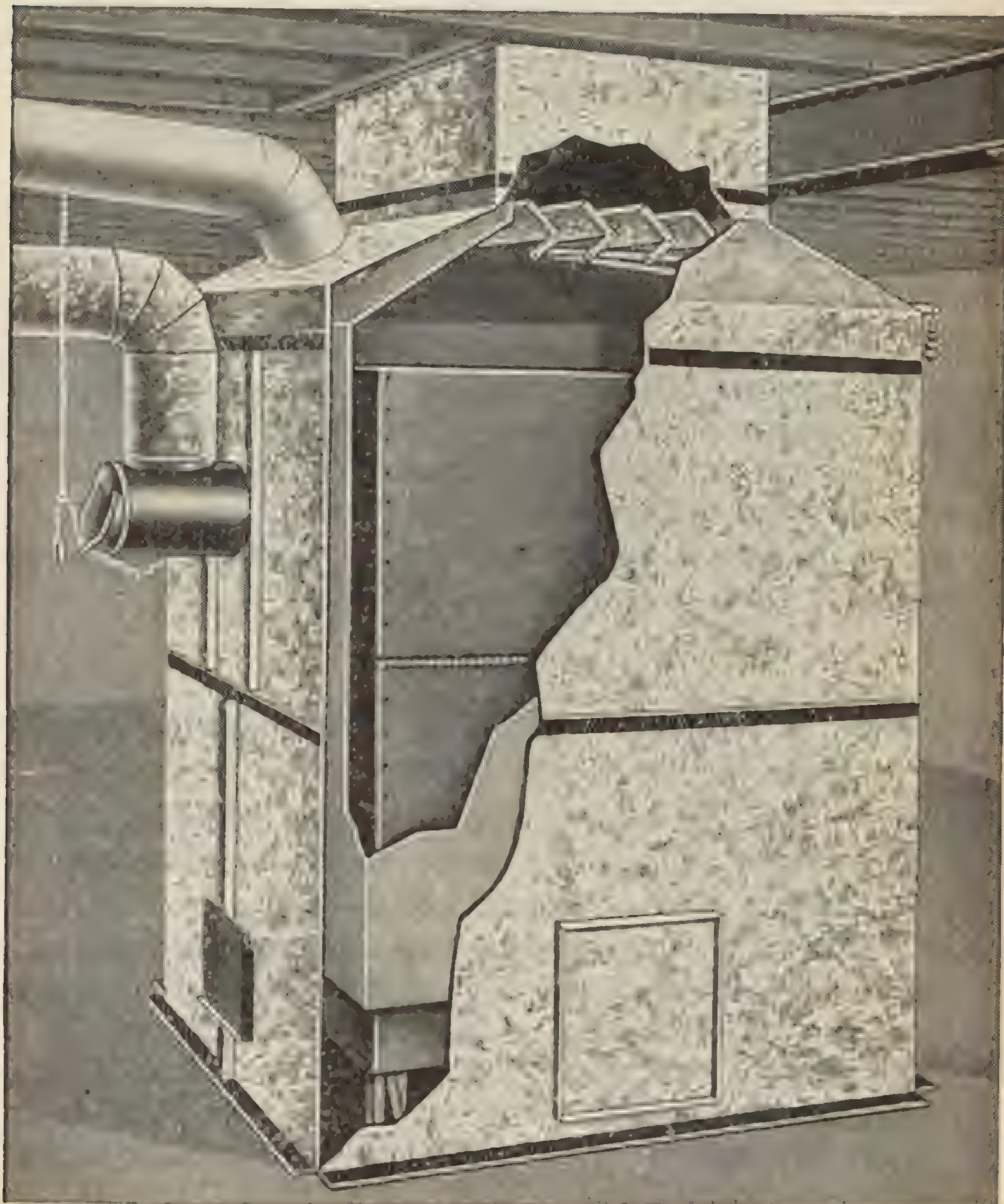


FIG. 8,415.—Deflecting valves as applied to pipeless furnace, to cause the current of hot air to divide, part to flow through the extra or smaller pipe.

Standard Code Regulating the Installation of Warm Air Furnaces In Residences.—This code is approved and issued by authority of the National Warm Air Heating & Ventilating Association; National Association Sheet Metal Contractors; Western Warm Air Furnace and Supply Association; The Midland Club.

ARTICLE NO. 1.

Meaning of the Term "Warm Air Furnace Heating Plant"

Warm air furnace heating plants, to which this code refers, shall consist of one or more warm air furnaces, enclosed within casings, together with necessary appurtenances thereto, consisting of warm air pipes and fittings, cold air or recirculating pipes, boxes and fittings, smoke pipes and fittings, registers, borders and face plates, the same being intended for heating buildings in which they may be installed.

ARTICLE NO. 2.

Provisions to be made in Building under Construction for Reception of Warm Air Furnace Heating Plants.

Section 1. (a) The following provisions shall be made by the owner or building contractor, in any building wherein a warm air heating plant is to be installed.

(b) Where warm air register boxes, heads, pipes or stacks are to be installed, joists shall be set not less than sixteen inches (16″) on centers and shall be butted and not lapped. Studding shall set directly over and under joists, leaving a space of not less than fourteen inches (14″) between studs and joists. Wherever joists are cut, headers must be put in to support joists.

(c) All first story single or sub-floors shall be continuous.

In all houses having studded exterior walls, these floors shall be extended to the outside sheathing and all spaces between studding shall be closed at the attic line.

Note 1. It is strongly recommended that the attic be tightly floored to reduce heat losses.

(d) All partition walls (or sections of these walls) in which heat stacks to second floor rooms are to be installed, shall be built of six inch (6″) studding to second story floor joists.

Chimneys

Section 2. (a) The owner shall provide a chimney for the furnace constructed in a manner to comply with the following specifications.

(b) The chimney must be absolutely smoke tight throughout its entire length, and must extend at least three feet (3′) above a flat roof or two feet above the ridges of peak roofs.

(c) If built of a single thickness of brick or of cement blocks, it shall be lined throughout its entire length with fire clay flue lining, having not less than three-fourths inch (¾″) thickness. Flue lining to be laid in mortar and made air tight.

(d) The furnace flue must have no other opening for attaching any fireplace, furnace, stove, range, water heater, gas or ventilating connection.

(e) If necessary to offset the flue, it must be done in such a manner as not to reduce the cross sectional area nor create a ledge or obstruction, where loose material may lodge.

(f) Its narrowest dimension shall not be less than eight (8″) inches and no flue smaller than 8″ x 8″ rectangular

or eight (8″) inch diameter round will be considered suitable when hard coal is to be burned, or 8″ x 12″ rectangular or ten (10″) inch round for soft coal or wood.

Note 2. *It is recommended that the height above the furnace grate be not less than twenty-six* (26′) *feet.*

Note 3. *It is strongly recommended that all new chimneys be built in strict accordance with the ordinance recommended by the National Board of Fire Underwriters.*

ARTICLE NO. 3.

Method for Determining Size of Warm Air Pipes, Wall stacks and Furnaces for Use in a Residence

Method of Determining Size of Basement Warm Air pipes.

(Read Explanatory Notes 4 to 11)

Section 1. First Floor Rooms.

Divide square feet of glass by 12.
Divide square feet of net outside wall by 40.
Divide cubic contents by 800.
Add together the above and multiply by 8.
The result is the area of the basement pipe.

$$\left\{\begin{array}{l}\text{The sum of:}\\ \left.\begin{array}{ll}\text{Glass (sq. ft.) (}\textit{Note}\text{ 4)} & \div 12\\ \text{Net Wall (sq. ft.) (}\textit{Note}\text{ 5)} & \div 40\\ \text{Cubic Contents} & \div 800\end{array}\right\}\times 8=\text{Area of Basement Pipe (}\textit{Note}\text{ 10)}\end{array}\right\}$$

Section 2. Second Floor Rooms.

Divide square feet of glass by 12.
Divided square feet of net outside wall by 40,
Divide cubic contents by 800,
Add together the above and multiply by 6.
The result is the area of the basement pipe.

$$\left\{\begin{array}{l}\text{The sum of:}\\ \left.\begin{array}{ll}\text{Glass (sq. ft.) (}\textit{Note}\text{ 4)} & \div 12\\ \text{Net Wall (sq. ft.) (}\textit{Note}\text{ 5)} & \div 40\\ \text{Cubic Contents} & \div 800\end{array}\right\}\times 6=\text{Area of Basement Pipe (}\textit{Note}\text{ 10)}\end{array}\right\}$$

Section 3. Third Floor Rooms.

Divide square feet of glass by 12,
Divide square feet of net outside wall by 40,
Divide cubic contents by 800,
Add together the above and multiply by 5.
The result is the area of the basement pipe.

$$\left\{\begin{array}{l}\text{The sum of:}\\ \left.\begin{array}{ll}\text{Glass (sq. ft.) (\textit{Note} 4)} & \div 12\\ \text{Net Wall (sq. ft.) (\textit{Note} 5)} & \div 40\\ \text{Cubic Contents} & \div 800\end{array}\right\} \times 5 = \text{Area of Basement Pipe (\textit{Note} 10)}\end{array}\right\}$$

Method of Determining Size of Wall Stacks.

Section 4. First Floor Rooms.

Same as Section 1.

Section 5. Second Floor Rooms.

Deduct 40% from basement pipe area determined in Section 2.

Section 6. Third Floor Rooms.

Deduct 40% from basement pipe area determined in Section 3.

Explanatory Notes

Note 4. *In obtaining glass surface use full casement opening. An outside door is figured as glass.*

Note 5. *To obtain net outside wall multiply height by width and deduct the glass in all windows and outside doors.*

Note 6. *For rooms having unusual exposure, ordinarily north, northeast and northwest, add* 15% *to pipe area. For east and west exposure, add* 10%.

Note 7. *For cold ceilings, add one-half net area of ceiling to net exposed wall (cold ceilings are those next to unfloored attics).*

Note 8. *Use no warm air pipe less than* 8 *inches in diameter.*

Note 9. *It is understood in using the above values for determining basement warm air pipe areas, that these pipes should be run comparatively*

straight and that they should not be over 10 *to* 12 *feet in length. Sharp turns and long pipes should have extra capacity.*

Note 10. *These formulas are for* 70° *inside temperature with zero temperature outside. For a temperature of* 10° *below zero, add* 10% *to the capacity of each pipe.*

Note 11. *The value of* 800 (*used in cubic contents*) *is for an estimated air change of one room volume per hour. If it is desired to provide for* 1½ *room volume use the figure* 600. *If for* 2 *room volumes use the figure* 400. *The factor of* 8 *in Section* 1 *will give a register temperature of approximately* 190° *in zero weather. Should a lower register temperature be desired, the factor* 9 *will give* 175° *at the register.*

Transition Fittings and Stacks

Section 7. Transition from warm air pipes to stacks shall be made with a well designed elbow or boot and no stack shall be less than 60% of the warm air pipe area.

Method of Determining Size of Registers.

Section 8. All registers shall have a free area at least equal to the calculated area of the basement pipe.

Method of Determining Size of Furnace.

Section 9. Add together the actual warm air pipe areas in sq. in. as obtained in Sec. 1, 2 and 3, and select a furnace having a free area not less than the sum of all the warm air pipe areas.

ARTICLE NO. 4.

Installation

Location of Furnace

Section 1. The location of the furnace shall equalize the length of warm air runs as far as possible, yet give necessary preference to pipes supplying living rooms, dining rooms and main halls.

Foundation

Section 2. Furnace foundation of brick, cement, or other

incombustible material must be provided. Said foundation to extend at least fifteen (15″) inches at rear and sides of furnace casing and at least thirty-six (36″) inches in front of furnace casing. Foundation to be level.

Setting or Assembling of Furnace

Section 3. (a) The base ring of the furnace shall be cemented to the foundation, making an air tight joint. The furnace parts shall be assembled plumb and level, and in a workmanlike manner.

(b) All sections and joints shall be properly fitted. Joints requiring cement shall be well filled and all bolts shall be drawn up tightly.

Casings

Section 4. (a) Warm air Furnaces shall be enclosed in metal casings or walls of brick, tile or concrete.

(b) Portable. Sheet metal casings including casing tops shall be made of galvanized sheets, not lighter than 26-U. S. Standard Gauge. They shall fit the castings and casing rings closely, so as to be dust tight, and shall be securely fastened to the front. The casing shall be lined from the upper casing ring down to a line on a level with the grate.

(c) When side collars are used the casing top must be of sufficient height so that the largest warm air pipe can be taken from side without ovaling. In no case shall a distance less than eight (8″) inches be maintained between the top of any furnace and the top of casing or bonnet.

(d) Any furnace, the casing top of which shall come within sixteen (16″) inches of a combustible floor, ceiling or joist, shall be protected by a metal shield, extending not less than eighteen (18″) inches beyond the casing of said furnace. This shield shall be suspended at least two inches

below wood work, allowing free air space between shield and woodwork. No furnace casing or top, coming nearer than six (6″) inches of ceiling or joists shall be allowed in any case.

(e) Openings for side casing collars shall be cut into the casing top, so that the tops of all openings are on a level. Casing collars shall be fitted into place with a proper flange, or bead on the outside and drawn up on the inside, making a dust-tight joint. All collars shall be of same size as the warm air pipes to which they are to be connected.

(f) Brick set, cement or hollow tile casings shall be constructed as follows: Walls shall be not less than eight (8″) inches in thickness, and shall be constructed air tight. Rectangular casing shall be, with least inside dimensions, the same as that of the portable casing of a corresponding size of furnace. Walls shall be carried to the same height as the portable walls, allowing not less than eight (8″) inches between the top of the furnace and the bottom of the top cover. After placing the collars for the warm air pipes, continue the masonry up even with the top of the collars, lay spacing rods of bar iron on edge or angle irons across the furnace top, cover these with sheet iron, cover the sheet iron with masonry and run the side walls four (4″) inches above the masonry bed. A galvanized iron casing bonnet may be used on brick set furnaces.

Provision shall be made in the walls for a manhole to give ingress to heater.

Warm Air Pipes in Basement

Section 5. (a) All warm air pipes shall be made of bright tin not lighter than IC, or galvanized iron. Side seams shall be locked seams. All points shall be either double seamed or lapped not less than one and one-quarter (1¼″)

inches and such joints shall be beaded and soldered or riveted. All pipes shall be properly secured to ceiling or joist. No solder or riveted joint is required where round pipe slips over the casing collar. Any pipe twelve (12″) inches or greater in diameter shall not be made of material lighter than IX tin or No. 26 U. S. Standard Gauge galvanized iron.

Note 12. *It is recommended that all warm air pipes in the basement shall have an upward pitch of not less than one* (1″) *inch per running foot.*

(b) No warm air pipe shall run within one (1″) inch of any woodwork unless such woodwork is covered with asbestos paper and the paper covered with tin or iron.

(c) All warm air pipes in the basement shall be provided with dampers not more than two feet from the casing.

(d) Where warm air pipes pass through a masonry wall, a metal thimble shall be provided, having a diameter at least 1″ greater than the pipe, and pipe supported in such a manner that the air space is uniform on all sides.

Wall Stacks

Section 6. (a) Single Stacks. All single wall stacks or wall pipes, heads, boots, ells, tees, angles and other connections shall be made of bright tin or galvanized iron and shall be covered with not less than one thickness of 12 lbs. per one hundred (100) square feet of asbestos paper. All studding and other woodwork facing said pipe shall be lined with metal and metal lath used in place of wood lath. An air space of not less than three-eighths (⅜″) of an inch shall be allowed on the two sides nearest the vertical studs. All such pipes shall be braced in a proper manner so as not to obstruct the flow of air but to retain the full capacity throughout. All joints shall be locked and held in place by means of lugs, or straps. No joint shall depend wholly upon solder to make it tight.

(b) Double Stacks. All double wall stacks or wall pipes heads, boots, ells, tees, angles and other connections shall be made of bright tin, not lighter than IC or galvanized iron and shall be made double, from and including the boot or foot piece in basement to the top of each and every stack and register head on all floors. There shall be continuous uniform air space of not less than five-sixteenths (5/16″) of an inch, which must be maintained between the outer and inner walls of all such pipes and fittings of all kinds, styles and descriptions; such pipes, heads, boots and other fittings to be of the styles, or equal to those accepted by the National Board of Fire Underwriters.

All pipes and fittings either single or double must be secured firmly in place by lugs or straps attached to the outer walls of stacks and fittings, and no nails shall be driven through these stacks or fittings at any point. No wall pipes or fittings shall be used which depend wholly on soldered joints. The various members shall be so made that all joints are locked and soldered and the several members shall be attached to each other with slip joints, which are, for the purpose intended, air tight.

Registers

Section 7. (a) When baseboard or wall registers are used, they shall be properly and permanently attached to the stack head in such a manner that will prevent any leakage of air between the head and the register.

(b) Floor registers shall be provided either with register borders, or double register boxes of tin or galvanized iron with an air space of not less than five-sixteenths (5/16″) of an inch between inner and outer boxes.

(c) Registers for warm air and warm air pipes shall not be located in outside walls. The warm air registers in the

various rooms shall be located in or near the inside walls in all cases.

Air Supply to Furnace

Section 8. (a) The air supply to furnace for warm air heating plants may be taken from outside or from within the building or may be taken partially from outside and partially from within. In no case, however, shall air be supplied to any furnace from any basement or furnace room.

(b) The cold air intake or return where air is taken from within the building shall have a net area throughout its entire length of not less than the combined net area of all warm air pipes leading from the furnace. This may be maintained in one or more ducts.

(c) When the cold air supply is taken wholly from the outside of the building the supply duct at its most contracted area must equal or exceed eighty (80%) per cent of the combined area of all warm air pipes leading from the furnace.

(d) Cold air ducts shall be constructed of metal, tile or other incombustible material having smooth inner surface and shall maintain a constant net area throughout their entire length and shall be made air tight. Where a boot or shoe is connected to the casing at the base, the opening shall not extend higher than a line on the level of the grate of the furnace. The width of the shoe shall be of proper measurement to make the area at least equal to that of the round or square pipe to which it is connected.

(e) Wherever the space between joists is used to convey cold air over head, the joists and all wooden surfaces between such joists shall be lined with metal and a sheet metal pan constructed to extend not less than six (6″) inches below said joists. The connection from this pan to the boot or

shoe shall be made of galvanized iron not lighter than No. 26 U. S. Standard Gauge, and shall have a transition collar, the top area of which shall be at least 10% greater than the area of the connecting pipe.

(d) The cold air face or faces shall be made of wood, or metal. When set in floors the top of same shall be flush with floor. Where cold air face is placed in a seat or side wall (whether furnished by owner, general contractor or furnace contractor) the open work of face must extend to within at least one (1") inch of the floor line.

The free area of cold air faces shall be at least 10% in excess of the free area of the duct or ducts to which they are connected.

Note 13. *The effective area of a vertical cold air face lies within twelve* (12") *inches of the floor line, hence, the capacity of any vertical cold air face shall be determined by multiplying the base line in inches by not to exceed twelve* (12") *inches in height and deducting for the grills or cross bars.*

Smoke Pipes

Section 9. (a) The smoke pipe shall be as short and direct as consistent with the location of the furnace. It shall be made of either black or galvanized iron not lighter than No. 24 U. S. Standard Gauge, and of the full size of the collar on the furnace throughout its entire length. It must have no other opening for attaching any fire place, stove, range, water heater, gas or ventilating connection. It shall be lock seamed or riveted; all joints shall lap not less than one and one-half (1½") inches and it shall be rigidly secured. Cast iron smoke pipe may be used.

(b) Where the smoke pipe enters the flue, a thimble shall be cemented into the flue and the connections thereto made air tight. Should any smoke pipe come within sixteen

(16″) inches of any combustible material, such combustible material must be covered with asbestos paper and a metal shield so fastened that a two inch air space exists between this shield and the combustible material. This shield shall be no less in size than twice the diameter of the smoke pipe and of sufficient length to cover the wood at all points.

(c) No smoke pipe shall project through any external wall or window.

Pipeless or One Pipe Furnaces

Section 10. (a) When but one duplex grating is used for both warm air and cold air in a so-called pipeless furnace, the area of the cold air intake shall be at least equal to the area of the warm air outlet of the grating. Art. 4, Sec. 4, relative to casing shall not govern when this type of furnace is installed, but the following specification shall be followed: The inner and outer casing of this type of furnace may be made of either black or galvanized iron not lighter than No. 26 U. S. Standard Gauge. A uniform air space shall be maintained at all points between the inner and outer casing. In no case shall the top of the furnace be allowed closer than twelve (12″) inches to any ceiling or joists above the furnace.

(b) Where joists are cut to accommodate this furnace, headers shall be put in and braced so as not to weaken the structure of the floor above the furnace.

(c) Article No. 3 for determining area of warm air pipe shall not govern in figuring a pipeless furnace.

(d) Where one warm air register face is used and separate face or faces for cold air supply are used, then Article No. 4, Sections 5 and 8 shall apply.

1

STEAM HEATING

This is a very effective, and sometimes too effective method of heating. In its various forms it is probably more widely used than any other system, being adapted to almost any type of building.

Some advantages of steam heating are the ability to heat all rooms uniformly, regardless of their location or the direction of the wind, a condition which seriously affects heating with hot air furnaces; steam is quickly raised in the morning and when a radiator is shut off, the small amount of condensation remaining is not sufficient to cause freezing.

The disadvantages are lack of control, and devitalizing effect on the air due to the high temperature of the radiating surfaces. The first objection has given rise to numerous modified systems of steam heating which render steam as a heating medium as satisfactory as hot water.

The various systems of steam heating may be classified:

1. With respect to the working pressure, as

   a. Low pressure (1 to 10 pounds).
   b. Atmospheric pressure (so called "vapor").
   c. Vacuum.
   d. Combined vacuum-vapor.

2. With respect to the method of piping, as

a. ***One pipe***
- relief
- circuit system
- divided circuit sysem
- circuit system with loop
- dry returns
- wet returns
- underconnected
- overhead

b. ***Two pipe***
- under feed
- over feed

3. With respect to the method of transmitting the heat, as

a. Direct.
b. Indirect.

LOW PRESSURE STEAM SYSTEMS

There are two principal low pressure steam systems, the **one pipe** and the **two pipe,** the circuit being modified in various ways to suit conditions.

When it is necessary to install steam heat in a long, narrow building, where the radiators are all placed along the outside wall, the one pipe system is especially suited.

For ordinary work it is preferred to the two pipe system, although the latter is in favor with some fitters. The cost of installation is less with the one pipe system, even with the smaller size piping used with the two pipe system.

It is customary when using the two pipe system to reduce the size of the main as the various radiators are taken off. Caution should be exercised not to overdo this, in order to guard against inefficient operation of the remote radiators, making it necessary to carry excess pressure on the boiler to insure proper operation of all the radiators.

One Pipe Underfeed Relief System.—There are various piping arrangements of the one pipe system. Fig. 8,416 shows what is called the one pipe relief system.

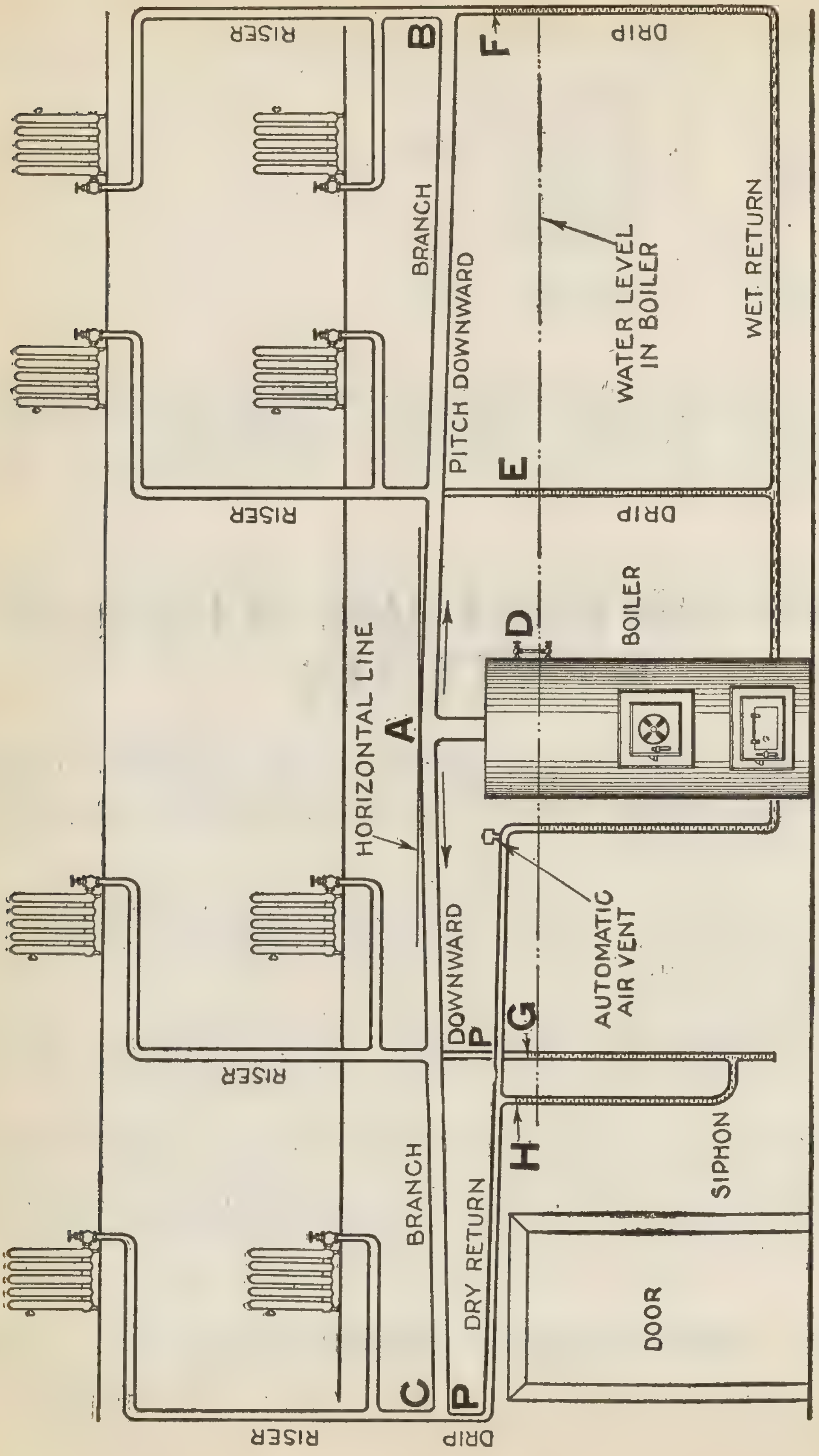


FIG. 8,416.—One pipe relief steam heating system showing 1, *dry* returns to the right, and 2, *wet* returns to the left. The wet return is the natural method of piping but frequently it is desirable to have the return elevated to near the ceiling where passing across doors, etc. This arrangement is called a dry return because it does not *fill* with condensation as when placed below the water level.

Connected to the main outlet A, are two or more branch mains, AB, and AC, which supply the various risers.

Steam is supplied to each radiator and the condensation removed by a single pipe or riser, hence the name, "one pipe system."

The condensation returns to the boiler by gravity through drip pipes, which are virtually continuations of the risers below the branch mains, and which connect with the return pipe so that the condensation will flow back into the boiler.

Ques. What is the difference between a wet or sealed, and a dry return?

Ans. A wet return is placed *below* the water level in the boiler, whereas a dry return is *above* the water level.

Fig. 8,416 shows both wet and dry returns.

Ques. What is the advantage of a wet return?

Ans. It seals the drips from the risers and prevents steam at a slightly higher pressure entering the return.

Ques. Describe the operation of the system shown in fig. 8,416.

Ans. Steam (usually at from 1 to 5 pounds pressure), passes from the boiler to the branches, AB, and AC; these branches being slightly inclined, any water in the steam drains into the drip pipe. The steam passes through the risers to the radiators, where its heat is radiated in warming the rooms, thus causing condensation. The risers being of liberal size, the condensation is carried by gravity against the direction of flow of the steam, and deposited in the drip pipes, where it gravitates via the returns to the boiler.

A characteristic feature of such systems is that there is a slight difference in pressure in the different parts of the system due to the frictional resistance offered by the pipe to the flow of the steam, this flow varying because of more rapid condensation in some radiators than in others. Thus, if the

water level in the boiler be at D, then in operation, with a wet return (fig. 8,416), the pressure difference will be balanced by the water standing at different levels in the different drip pipes, as at E, and F.

When it becomes necessary to carry the return pipes overhead to clear doorways, or for any other reason, the effect of a wet return may be obtained by attaching a *syphon* to the bottom of the drip pipe as shown at the left in fig. 8,416. The water from the drip falls into the loop formed by the syphon and after it is filled, overflows into the dry return. The water will rise to different heights G, and H, in the legs of the syphon to balance the difference in pressure at points P, and P′. Now, if the syphon were omitted and the drip pipe connected direct to the dry return, then there would be a tendency for the condensate in the dry return to back up instead of draining

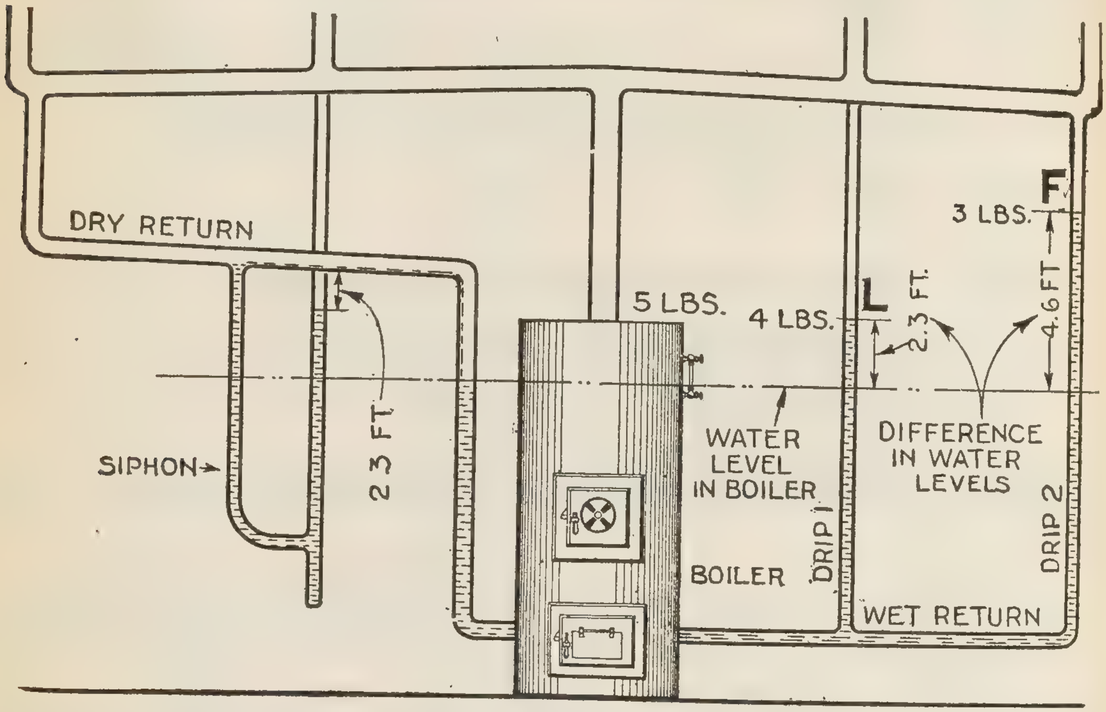
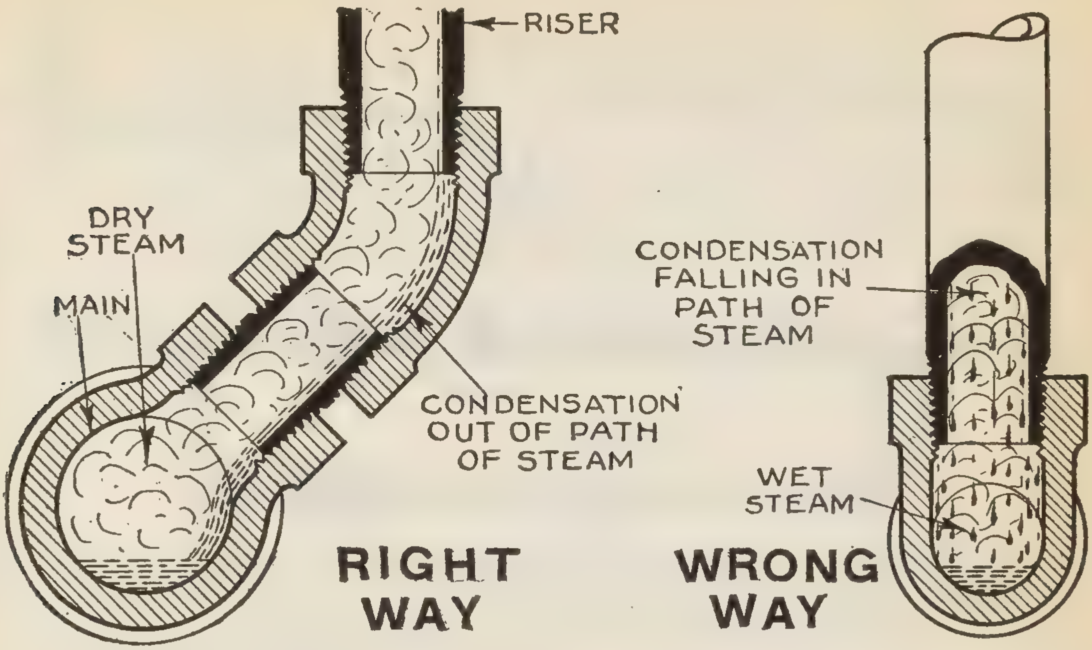


FIG. 8,417.—Detail of boiler and returns of fig. 8,416, showing effect of pressure variation in different parts of the system. ***In general,** there is a gradual reduction of pressure as the steam flows from the boiler to the remote parts of the system.* This is due to the frictional resistance offered by the pipe and fittings to the flow of the steam. Hence this variation in pressure ***only** exists when the steam is flowing in the pipes and in order for the steam to flow in the pipes there must be* ***condensate.*** Now, in the figure, when the plant is in operation with condensation taking place in the radiators and draining into the drip pipes, suppose the pressure in the boiler be 5 lbs; in drip 1, 4 lbs; and in drip 2, 3 lbs. Then, to balance these pressure differences the water will rise in drip 1 to L 2.3 ft. above the water level in the boiler because there is a pressure difference of 5—4 = 1 lb. and the weight of a column of water 2.3 ft. is 1 lb. for each sq. in. of cross section. Similarly, for drip 2, the pressure difference is 2 lbs., hence the water will rise twice this distance above the water level in the boiler, or 2.3 × 2 = 4.6 ft. to balance the 2 lbs. pressure difference.

into the boiler because the pressure in the drip pipe at P, is greater than the pressure in the dry return. Fig. 8,417 shows in detail the effect of pressure variation.



FIGS. 8,418 and 8,419.—***Right*** and ***wrong*** way of connecting risers to mains. A good many steam fitters to avoid extra labor and expense connect risers direct to the main with simply a tee as shown in fig. 8,419. It requires no deep thought to understand that some of the condensation from the radiators above falling into the main directly in the path of the steam flowing through the main will be taken up and carried by the steam into the next riser, thus arriving at the radiator with considerable more moisture than would be the case if the piping were arranged as in fig. 8,418, where the condensation would run down the side out of the path of the steam. According to one authority, the saturating and cooling effect occasioned by piping the wrong way as in fig. 8,419 may reduce the efficiency as much as 5%.

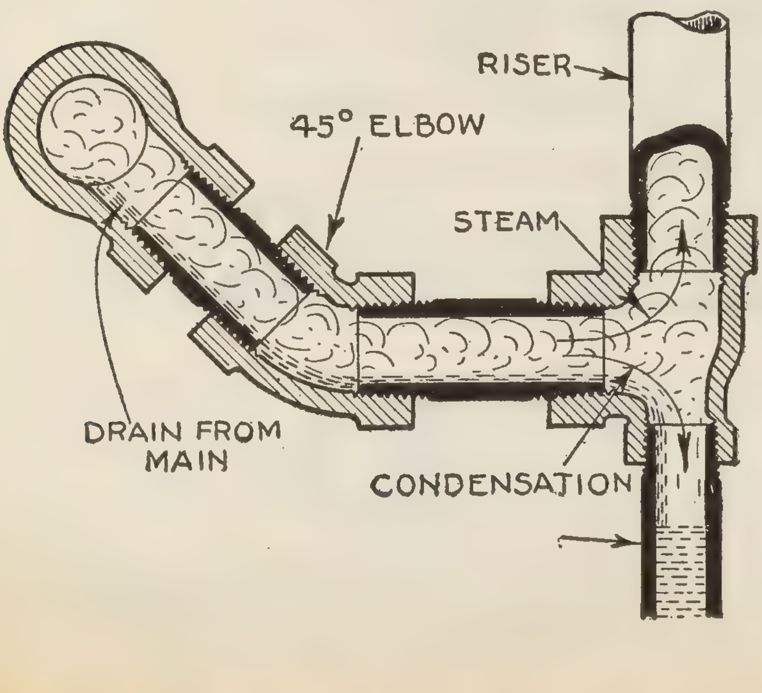
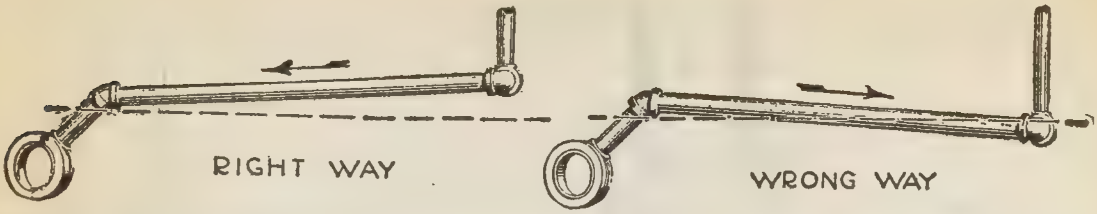


FIG. 8,420. — Proper method of connecting riser to main where riser has direct connected drip pipe. By using a 45° street elbow only one nipple is required. With this arrangement the main is very effectively drained of condensation, thus increasing the efficiency of the system.



FIGS. 8,421 and 8,422.—Right and wrong methods of connecting main to riser.

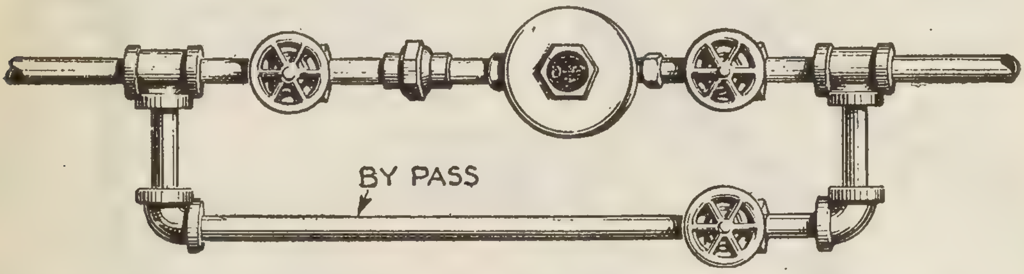
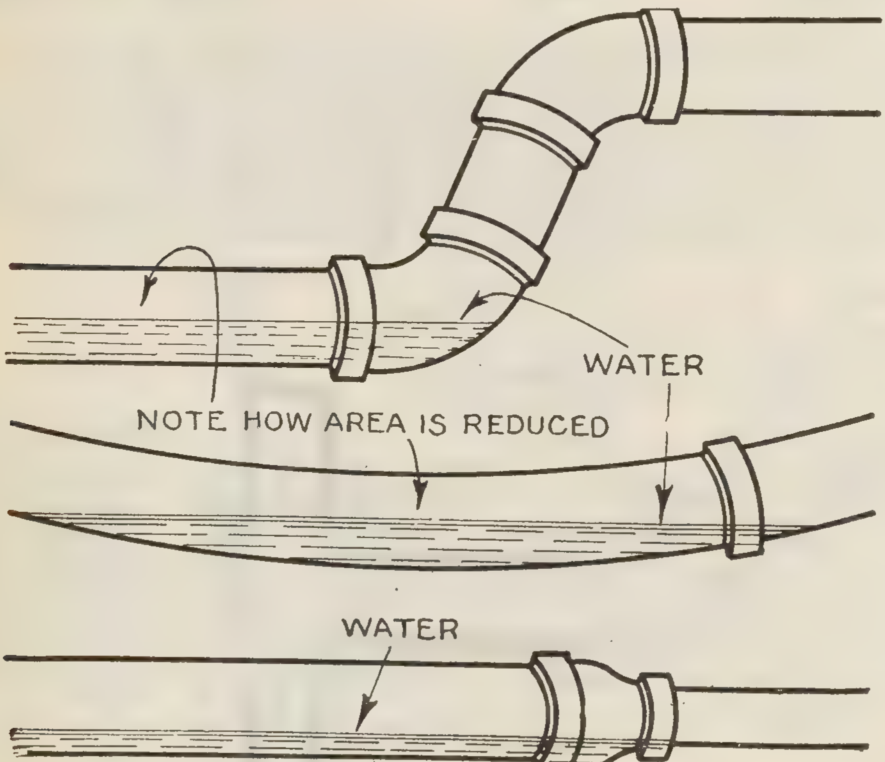


FIG. 8,423.—Method of by passing a trap. ***It is good practice***, though not necessary except in special cases, to install each trap with a by pass, with valve on either side of the trap and in the by pass.

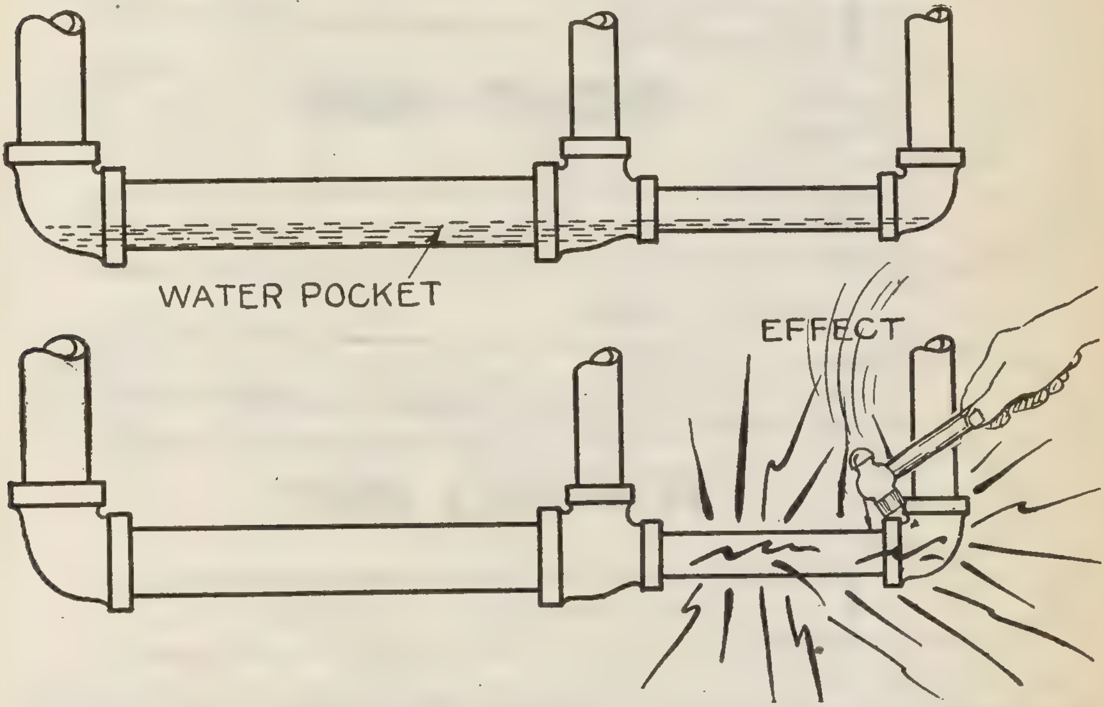


FIGS. 8,424 to 8,426.—Faulty piping methods. Fig. 8,424 shows a water pocket formed because of lack of pitch, and fig. 8,425, another pocket formed by sag in pipe. These pockets reduce the area available for the flow of steam with resulting loss in efficiency. Fig. 8,426 shows a water pocket formed by reducing without using an eccentric fitting.

Ques. How should the risers be connected to the steam mains, and why?

Ans. 45° elbows should be used so that the condensation will drain along the metal of the pipe and fittings instead of dropping directly into the steam, which would tend to saturate and cool the steam.

Figs. 8,418 and 8,419 show the right and wrong way of connecting risers to main.



FIGS. 8,427 and 8,428.—"Water hammer" caused by using ordinary fittings on mains instead of eccentric fittings. ***In some instances*** (especially on long lines), a sudden rush of steam through the pipe will hurl the water against the elbow at the end with such violence as to fracture it, producing the same effect as though the fitting were struck a violent blow with a hammer.

Ques. Where the riser is connected direct to a drip pipe, how should it be connected to the main?

Ans. By a 45° elbow looking downward, as in fig. 8,420.

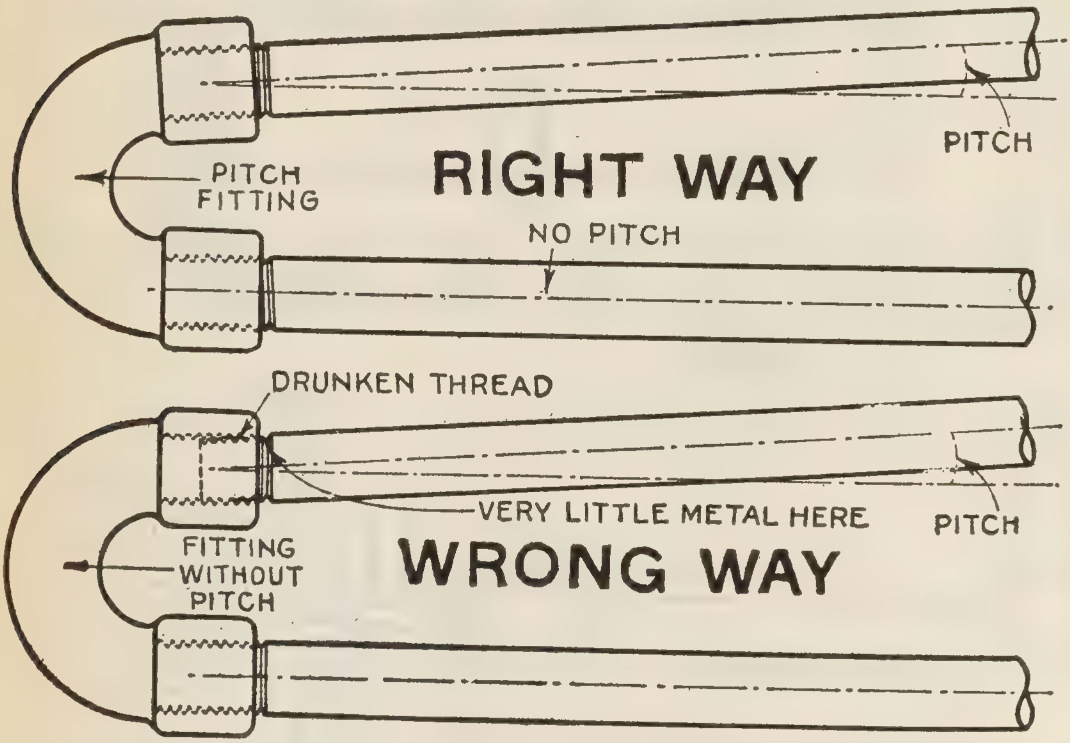
Ques. How are water pockets avoided in reducing the size of mains?

Ans. By the use of eccentric fittings.

Fig. 7,887 and 7,888, (page **1,993**) show eccentric reducing tees.

Ques. Why is such precaution advisable?

Ans. Because a sudden rush of steam occasioned by opening a radiator might take up the water and project it with great velocity and force against any turn in the direction of the main, this effect being known as water hammer.



FIGS. 8,429 and 8,430.—Right and wrong way of making up coils and lines where *pitch* is required for drainage. In first class work, "pitch fittings" are used to secure the proper inclination of a pipe, but on the usual botch job, an ordinary fitting is used and a "drunken thread" cut on the pipe. Evidently such method of threading not only gives a poor joint, but one which because of the deep cut on one side of the pipe is liable to leak in time by eating away of the thin metal due to corrosion. On heating jobs such work should be rejected.

Ques. What trouble is sometimes encountered with radiators located at elevations near the level of the water in the boiler, and why?

Ans. On long lines where there is considerable reduction of pressure, the water sometimes backs up into the radiator, as in fig. 8,431, thus interfering with its operation.

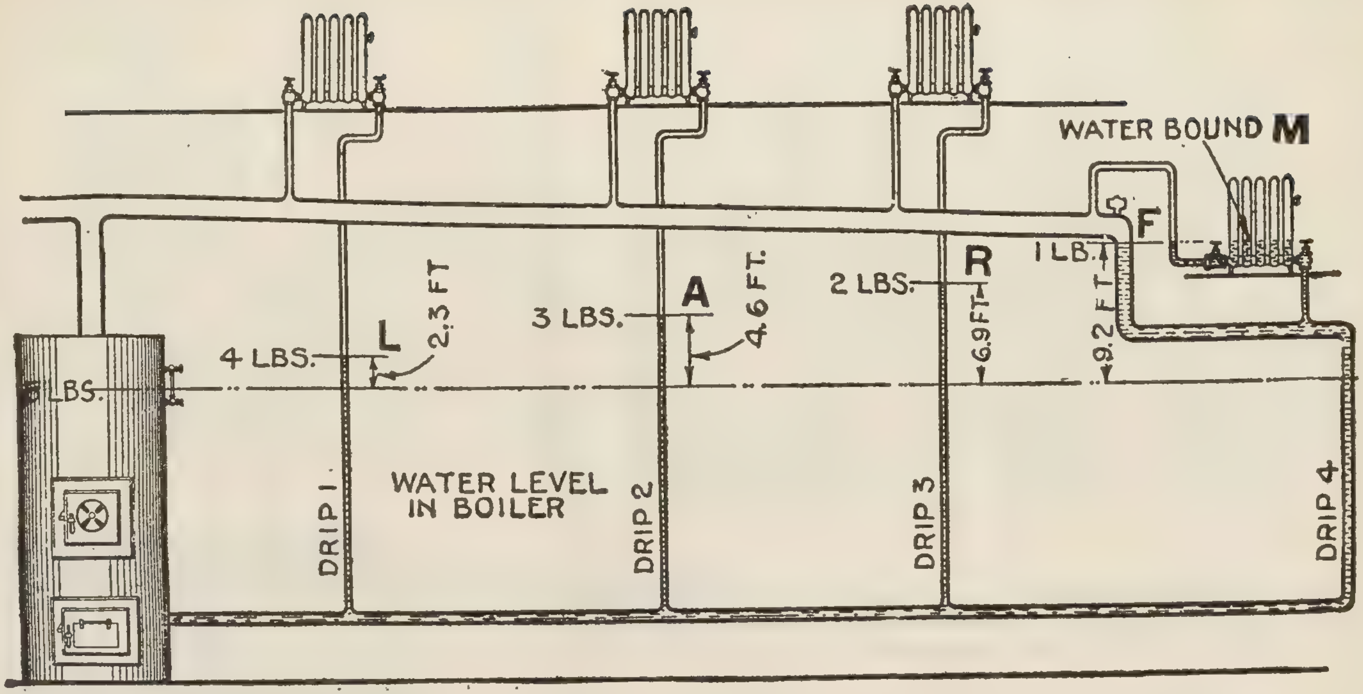


FIG. 8,431.—Water "backing up" in radiator on end of long line. ***Owing to pipe friction*** there is a gradual reduction of pressure in the main from the boiler to the end of the line, the water rising in the return pipes to gradually increasing elevations as **L**, **A**, **R**, **F**, to balance these pressure differences, the pressure difference being so great at radiator **M**, as to bring the water level **F**, in the return pipe high enough to partially flood the radiator. Hence, on the pressure differences at a remote point will depend the height at which the radiator must be placed to avoid this trouble. Water levels in return pipes (to save space) are not to scale.

Ques. How may radiators be operated at elevations below the water level in the boiler?

Ans. By means of a steam loop, as shown in fig. 8,433.

One Pipe Overhead System.—This arrangement is well adapted to tall buildings, because if the radiators were fed from the bottom, the risers would have to be

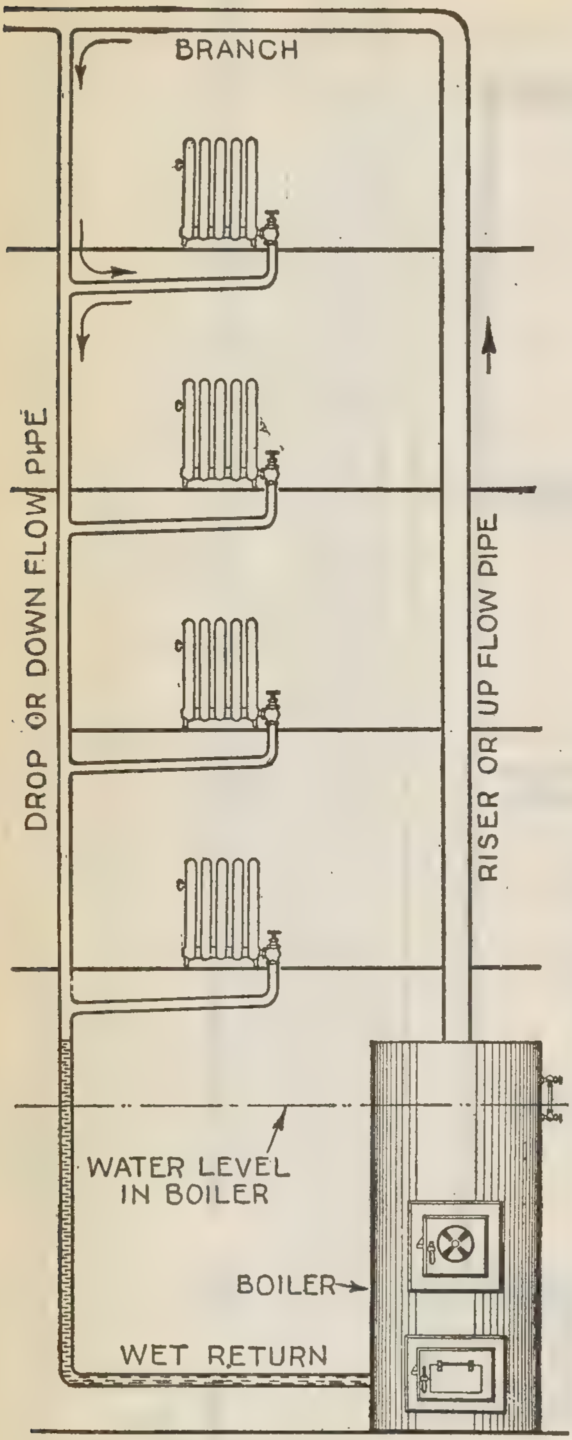


FIG. 8,432.—So called "one-pipe" overhead system as installed in tall buildings. Its features are uniflow of steam and condensation, which permits the use of smaller pipes.

excessively large. Instead of a steam main encircling the basement it is carried directly to the attic, forming a central riser for all the radiators. It branches in the attic to the drops or down flow supply pipes, which serve the various radiators as shown in fig. 8,432.

Since steam and condensation flow in the same direction in the down flow pipes and the riser contains only steam, these pipes can, as must be evident, be smaller than in the under connected system, as shown in fig. 8,416.

One Pipe Circuit System.—For a rectangular building of low or moderate height the steam main is conveniently carried entirely around the basement. Risers are tapped from the main at various points to serve the radiators. The main being inclined from beginning to end, the condensation drains in the same direction as the

steam flows, being carried to the drip pipe, thence into the boiler, Since there is no return pipe as with the relief system, the circuit arrangement is less expensive to install.

Fig. 8,434 shows the general arrangement of the system, it being the same as the relief system with exception of the steam main, and absence of a return.

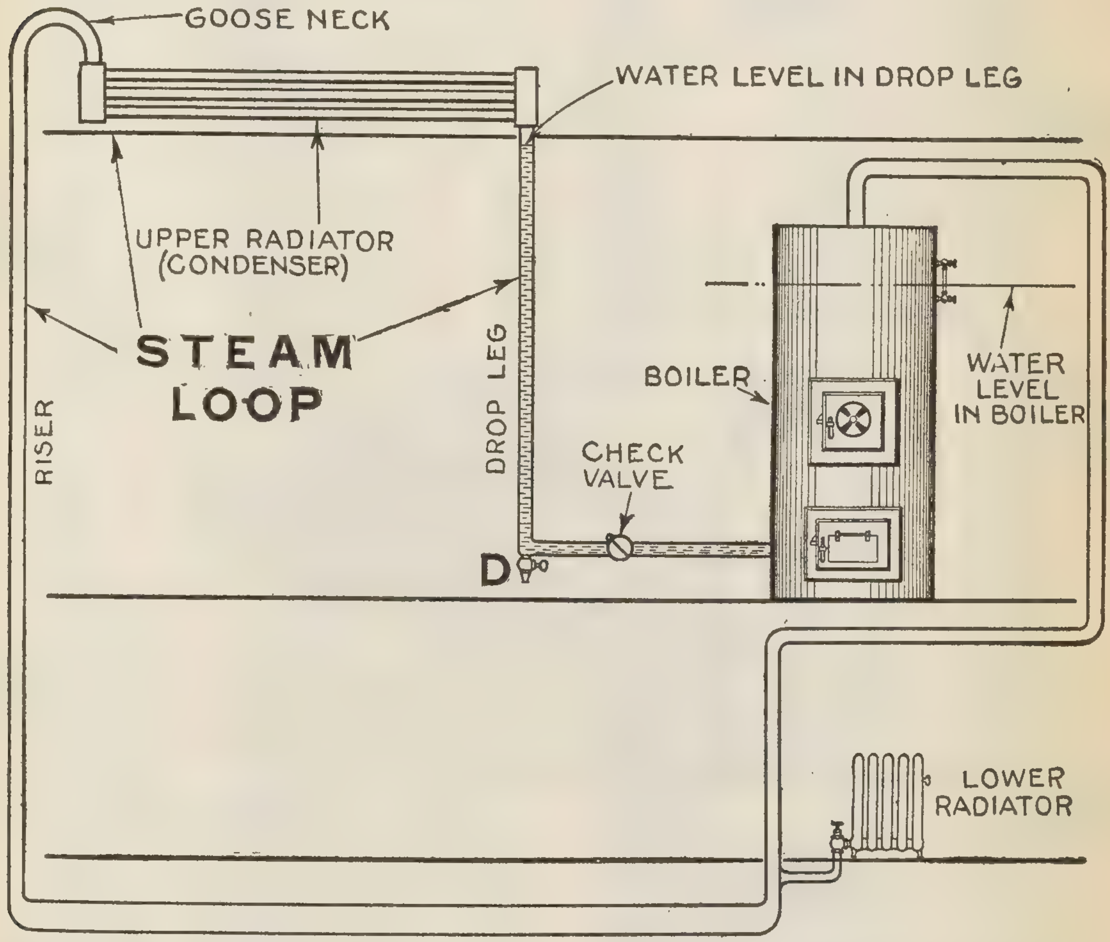


FIG. 8,433.—Steam loop method of operating radiator placed below level of water in boiler. In the steam loop the condenser element may consist of a pipe radiator placed on floor above boiler. The liberal condensing surface thus provided will render the loop very active in removing the condensation and at the same time the heat radiated from the condenser is utilized in heating. The drop leg is provided with a drain cock D, and the connection to boiler, with a check valve. ***To start the system,*** turn on steam at the boiler and open D, until steam appears. The condensation of steam in the condenser (upper radiator) will cause a rapid circulation in the riser, carrying with it the condensation from the radiator, which, in passing over the *goose neck*, cannot return but must gravitate through the upper radiator and *drop leg* past the check valve and into the boiler. The pipe at the bottom of the main riser which acts as a receiver for the condensate from the lower radiator, should be one or two sizes larger than the pipe in the main riser.

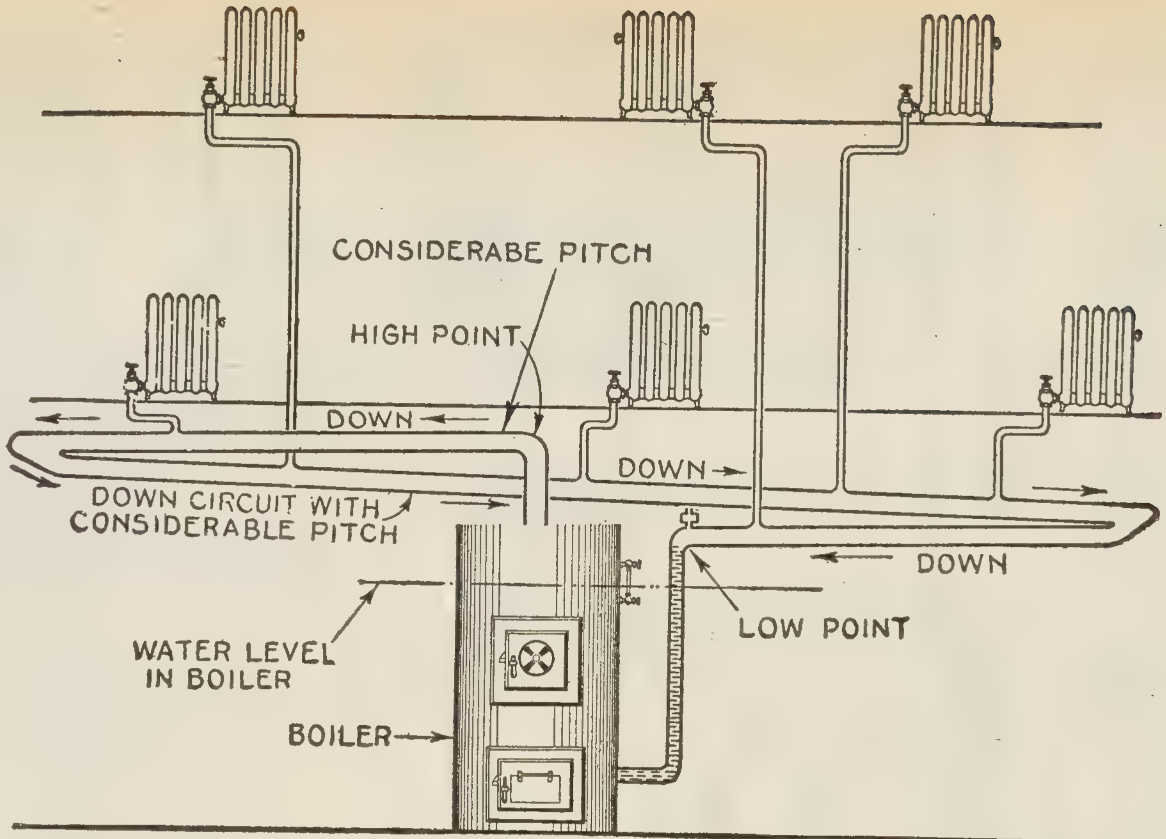


FIG. 8,434.—One-pipe circuit system. Since there is no relief, the condensation must traverse the entire circuit of the steam main, hence it must be given considerable pitch. It is not necessary that the pitch be uniform but, as must be evident, it should increase after each riser tap. Where there is little head room this will prove the more efficient arrangement. The diagram shows the general features of the system.

One Pipe Divided Circuit System.—This arrangement is suited to long buildings with boiler located near the center, the circuit being divided at A, fig. 8,435, that is, each end is connected to a drip pipe connecting with a return, giving separate seals for each end.

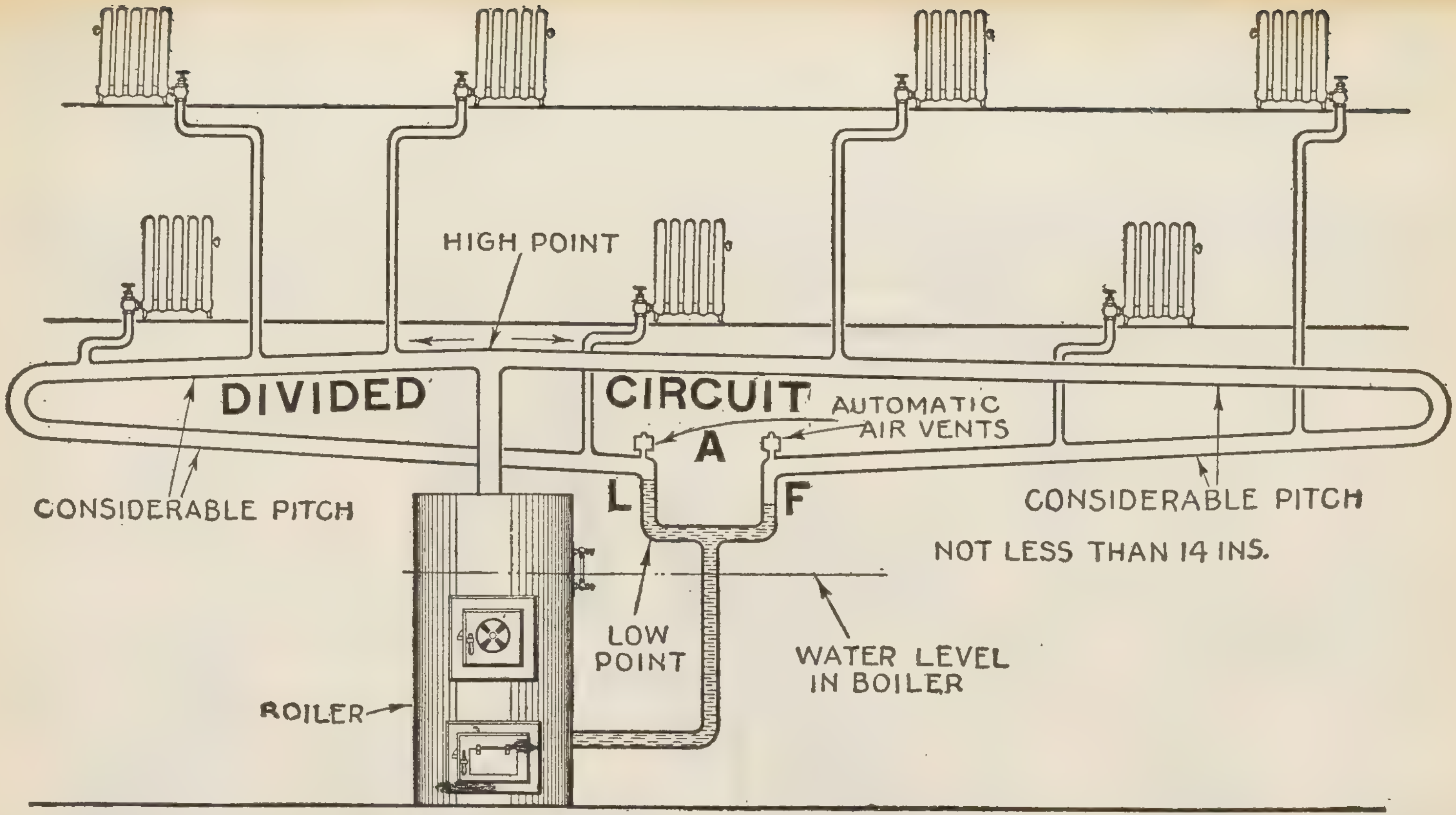


FIG. 8,435.—One pipe divided circuit system. Suitable for long buildings with boiler near the center. Since two paths are offered for the steam to the risers, evidently the size of the main can be less than where the entire flow passes through a single line; this then is a saving in installation. Moreover, for unequal distribution of the radiation, the main can be proportioned accordingly, reducing the cost of piping to a minimum. Automatic air vents should be placed at the end of each arm, as shown.

For proper operation these ends should not be at a less elevation than 14 inches above the boiler water level. The individual seals make the two halves of the divided circuit independent, which is desirable for unequal loads. Thus there may be considerable difference between the pressure at L, and F, each being what is necessary to balance the load.

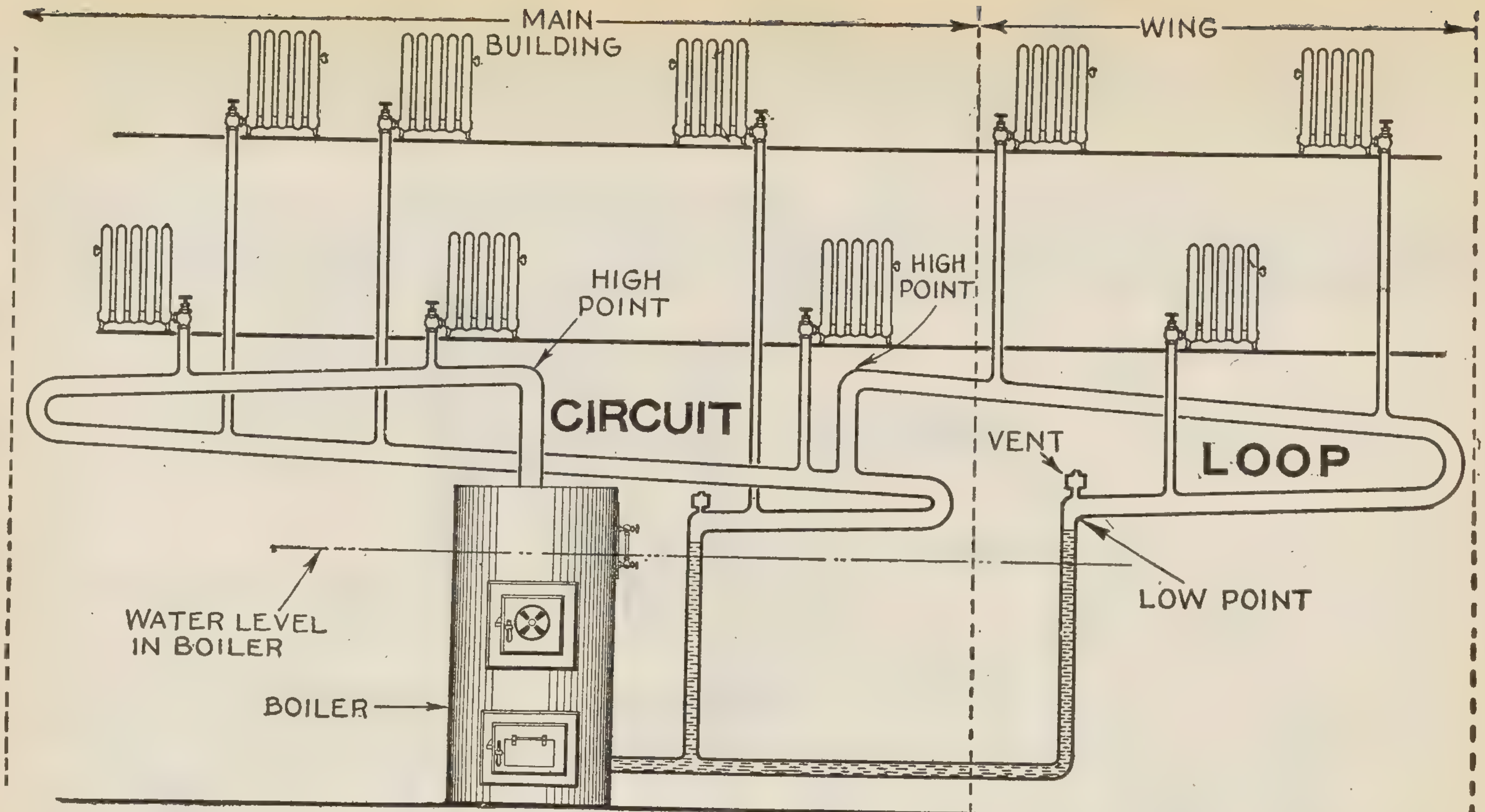


FIG. 8,436.—One-pipe circuit system with loop suitable for L-shape buildings, the circuit serving the main building, and the loop the wing. There are two high points in the steam main piping, thus both circuit and loop may have ample pitch (which is essential for proper drainage), without undue head room. The circuit leads directly to the boiler, but a return is placed between the end of the boiler and loop. Both circuit and loop should be provided with an automatic air valve as shown. For ideal conditions the pitch of both circuit and loop should be increased at each riser connection.

One Pipe Circuit System with Loop.—This forms a convenient arrangement for an L-shaped building, a circuit being used for the main building and a loop (tapped from the circuit), serving the wing.

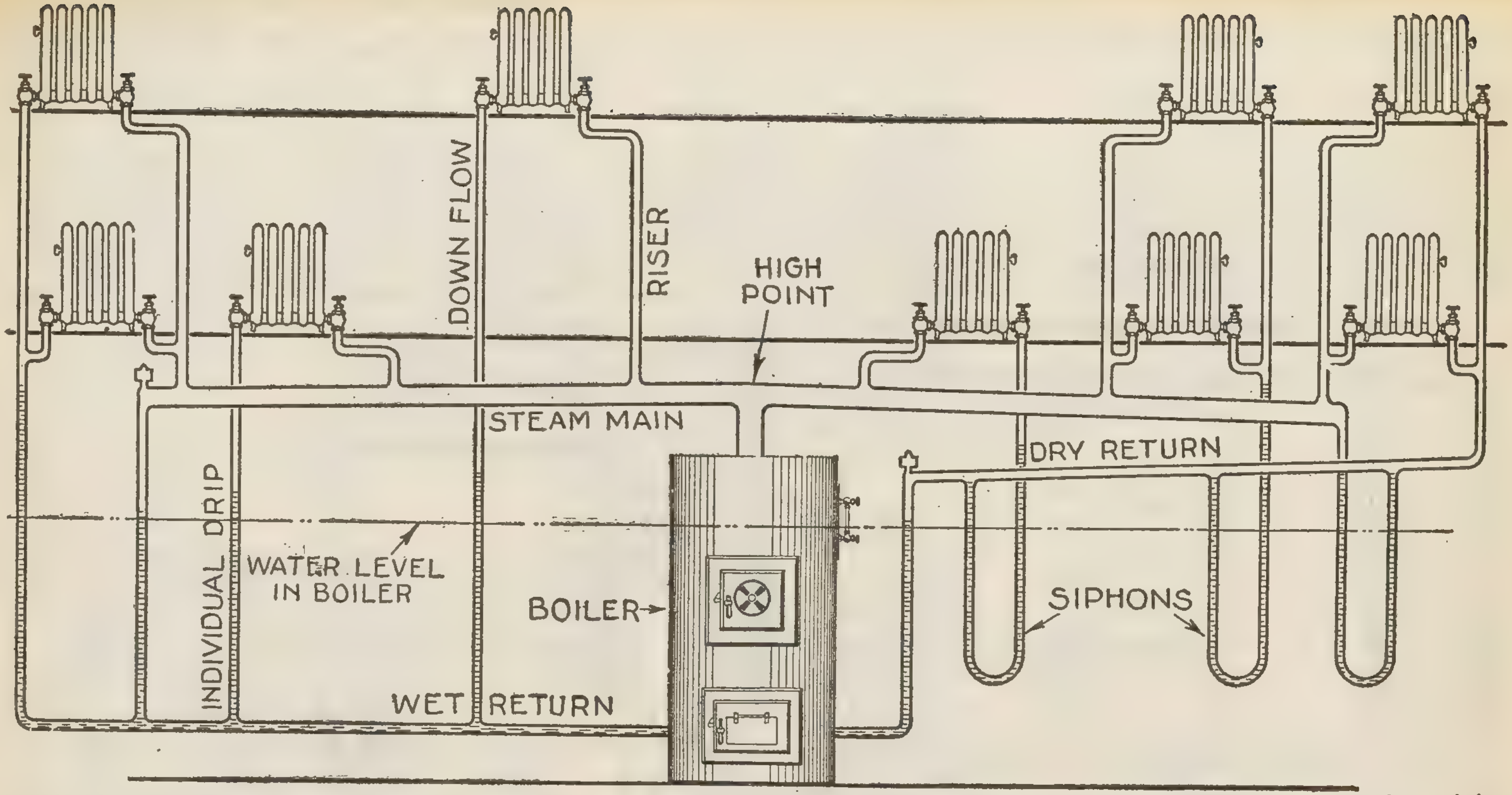


FIG. 8,437.—Two pipe system. Steam and return mains are employed the same as with the one pipe system. Various piping arrangements are used for these, such as circuit, divided circuit, loop, etc., as will best meet the requirements of the buildings. Dry or wet returns may be used. Steam is supplied to the radiators through risers and the condensation returned through down flow or drip pipes, as shown. Smaller pipes for both risers and down flows are used than in the one pipe system, the cost notwithstanding is greater than for the pipe system, hence the popularity of the latter.

In this system there will be two high points; one at the beginning of the circuit and the other at the beginning of the loop, thus giving ample margin above the boiler water line for liberal pitch in both the circuit and loop. Fig. 8,436 shows the general features of the system.

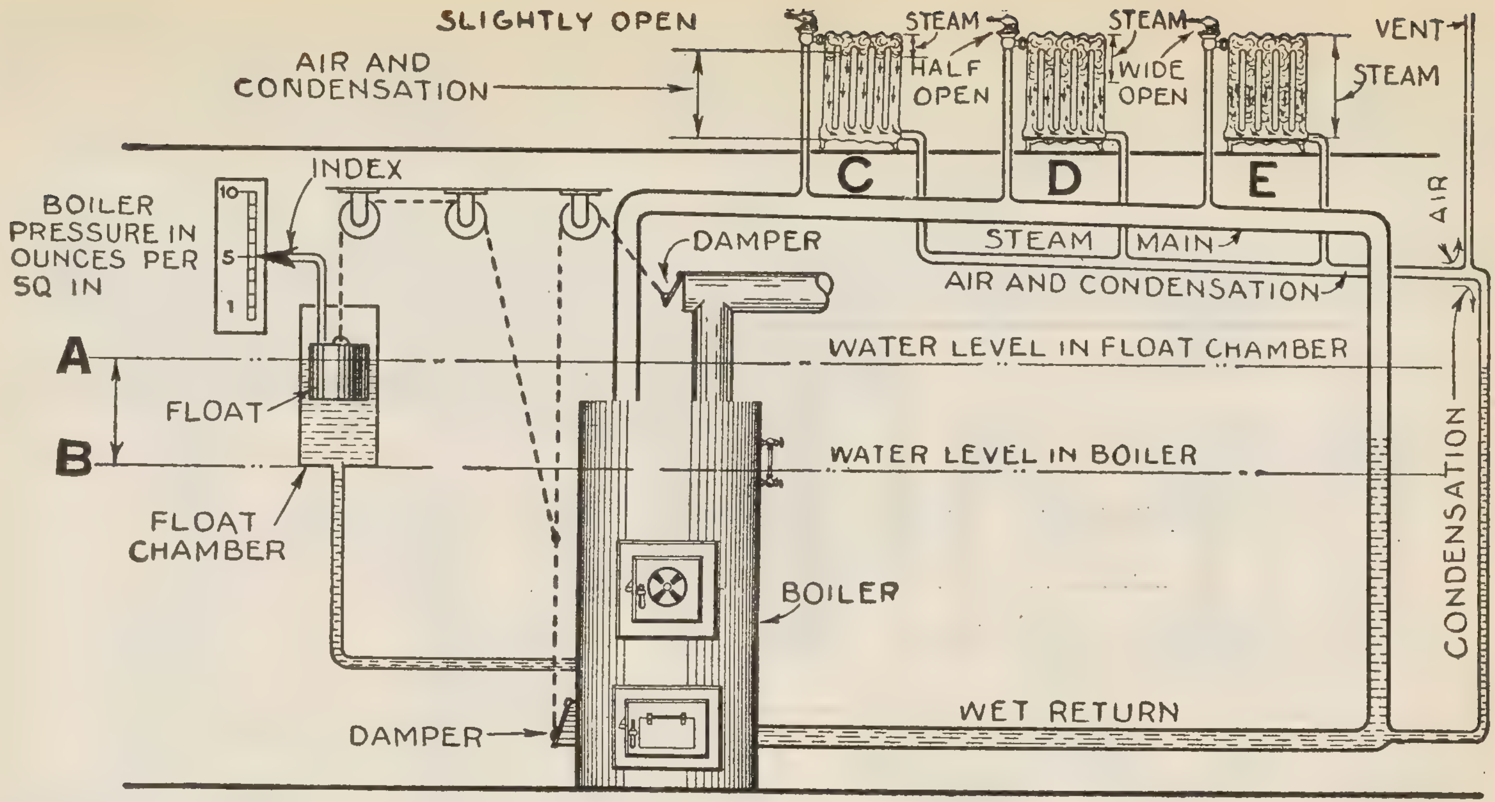
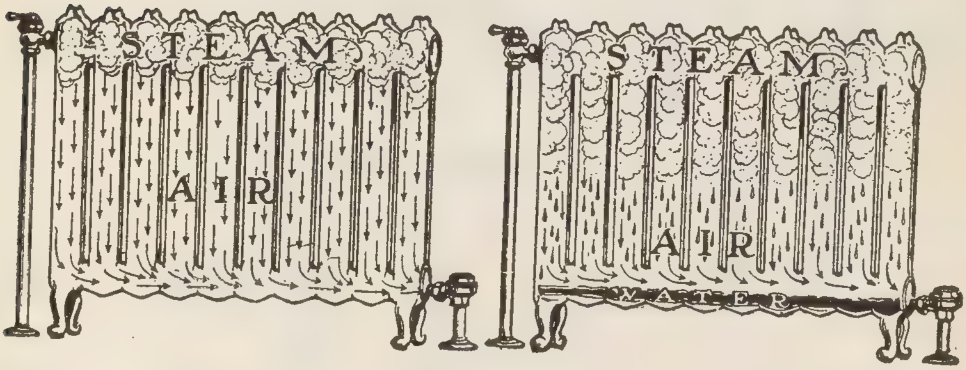


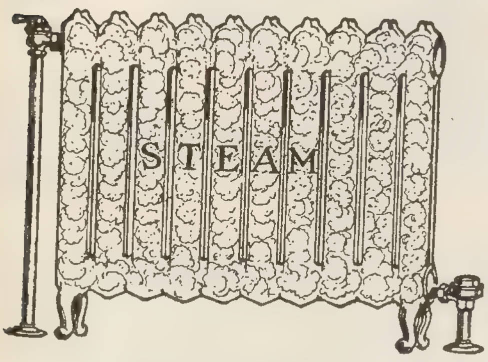
FIG. 8,438.—Atmospheric pressure or so called vapor system. Pressure at boiler one to five ounces or enough to overcome the frictional resistance of the piping system; pressure at vent zero gauge or atmospheric. ***In operation*** steam is maintained at about five ounces pressure in the boiler by the action of the automatic damper regular. The amount of heat desired at the radiators is regulated by the degree of opening of the supply valve. Steam enters at the top of the radiator and pushes out the air through the outlet connection which is open to the atmosphere. The condensation returns to the boiler by gravity. This system has the advantage of heat adjustment at the radiator, but the devitalizing effect in the air is somewhat greater than in the vacuum systems because the steam entering the radiators is at a higher temperature, the steam of lower pressure in the vacuum system. It is, however, simple.

Two Pipe System.—In this system separate pipes are provided for the steam and condensation, hence they may be of smaller size than where a single pipe must take care of both steam and condensation.

Any arrangement of the steam and return main, such as the relief circuit, divided circuit, etc., may be adapted to suit the requirements of the building. Risers are connected to the steam main at suitable points to serve the radiators, and down flow or drip pipes connect the radiator outlets with the return main, as shown in fig. 8,437.

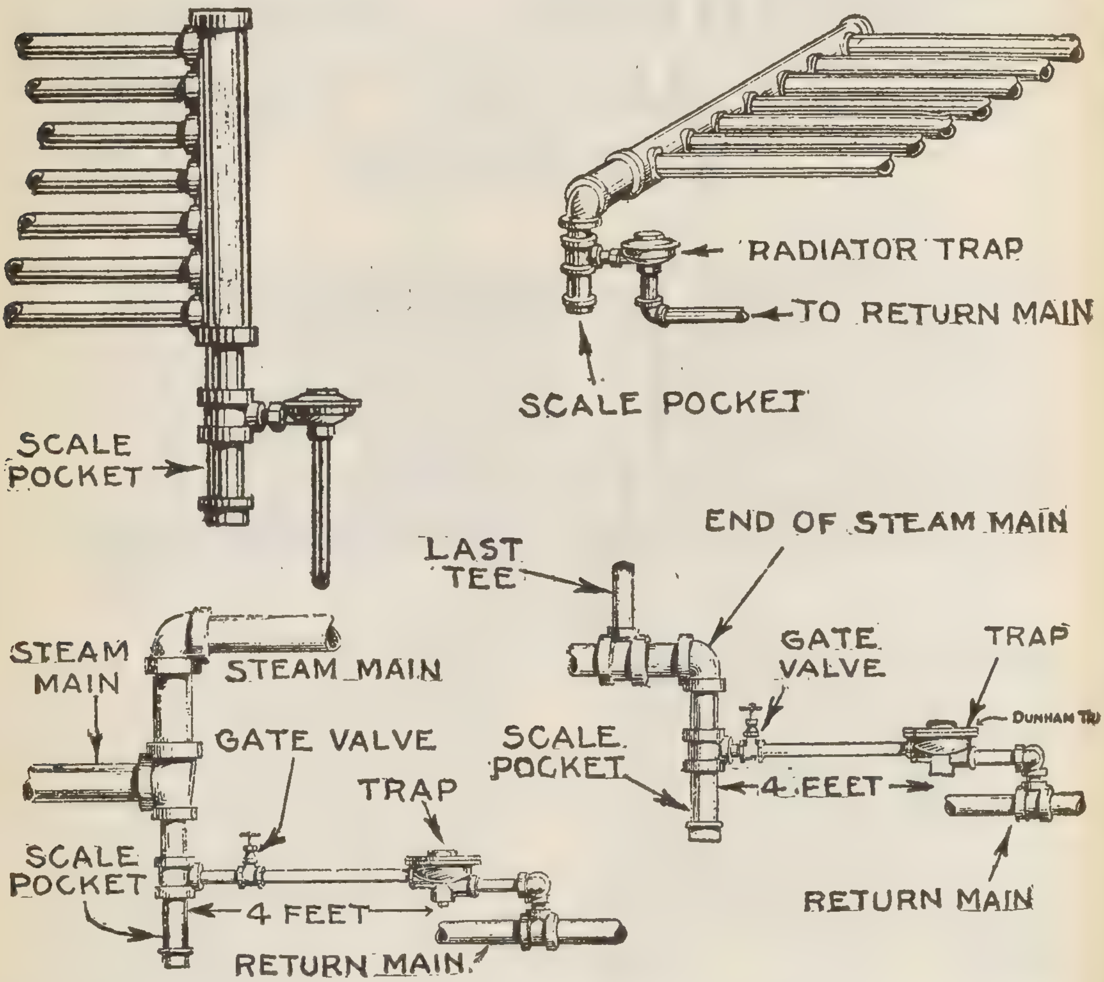
ATMOSPHERIC PRESSURE OR SO CALLED "VAPOR" SYSTEMS





FIGS. 8,439 to 8,441.—Operation of down flow vapor-vacuum radiators. Fig. 8,439, steam entering, air passing out through thermostatic retainer valve; fig. 8,440, more steam entering, condensation and balance of air passing out through trap; fig. 8,441, radiator full of steam, thermostatic retainer valve closed. As steam enters a cold radiator it forces the cool air which is in the radiator out through the trap into the return piping. In warming the radiator, the steam gives off heat and in doing so condenses to water. The water which is heavier than steam falls to the bottom of the radiator and flows to the trap through which it also passes into the return piping. After forcing out the air the steam fills the radiator and follows the water to the trap which in the presence of steam automatically closes because the steam is hotter than either the air or water. The heat of the steam expands the valve control element, closing and holding the valve against its seat with a positive pressure, thus trapping the steam within the radiator. The radiator now thoroughly filled with steam gives off heat condensing the steam at a uniform rate and the water of condensation which is cooler than the steam flows in a steady stream to the trap which it slightly chills causing it to open allowing the water to pass out. The trap adjusts itself to a position corresponding to the water temperature just as a thermometer does to the room temperature, and permits a continuous flow of water from the radiator.

If manufacturers of special steam heating systems working at atmospheric, or less than atmospheric pressure, would stop trying to appear learned by using such studied terms as *fractional control*, *modulation*, *thermo-seal*, **vapor,** *syphon*, etc., etc., in describing their apparatus, and get down to plain English, so as



FIGS. 8,442 to 8,445.—Dunham piping suggestions for traps. Fig. 8,442, trap used on wall coil; fig. 8,445, trap used on ceiling coil; fig. 8,444, trap used on deep end of steam main; fig. 8,445, trap used to disperse in steam main. ***In applying,*** traps to pipe coils they should be installed as here shown. ***A scale pocket*** *should be provided at the bottom of the return header and in front of the trap*. When a trap is used for dripping steam piping it should be installed with at least four feet of connecting piping between it and the point dripped. A liberal scale pocket should be provided also a valve in the connection to the trap. When used for dripping the end of a steam main, the latter should enter beyond the last used connection and be provided with a full sized scale pocket. A rise or jump up in a steam main is dripped as in fig. 8,444. Down feed risers require individual drips and traps.

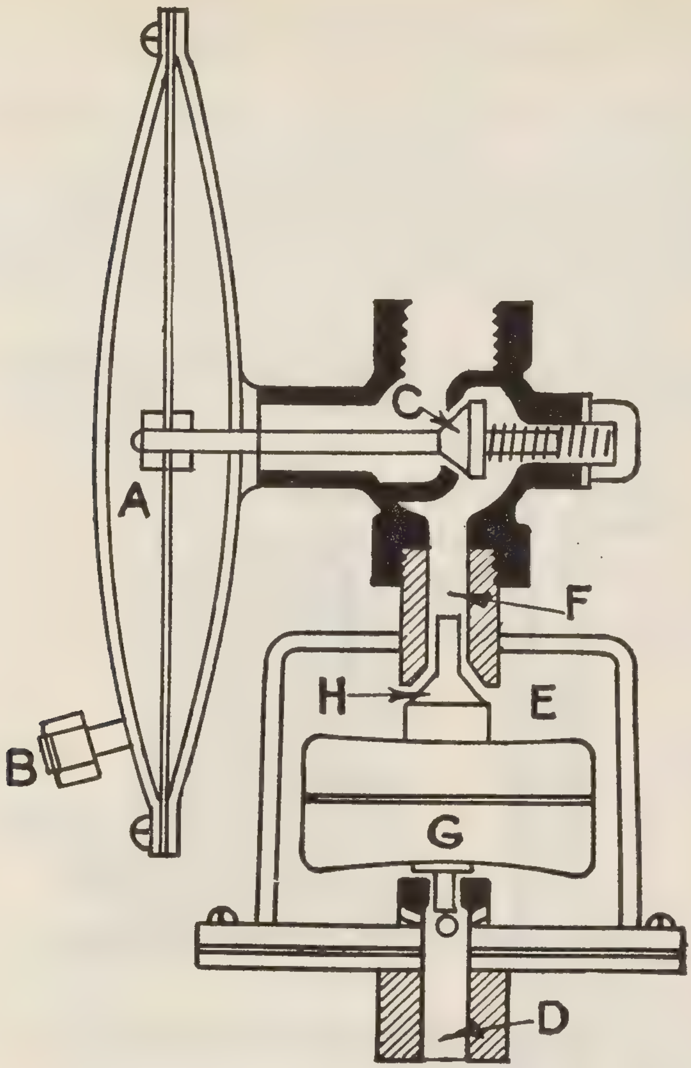


FIG. 8,446.—Dewey tri-duty air and vacuum trap as used on the Imico combined atmospheric pressure and vacuum system. This trap is placed on the return line not less than 27 ins. above water line. Diaphragm A, is attached to pressure main by small copper tube at B, nominally valve C, stands closed and held to seat by light coil spring. When fire is started in heater, air is expanded and inflates diaphragm A, and opens valve C, which remains open as long as there is any pressure on boiler. The steam passes into radiators at the top forcing air into return line and out through opening D, into float chamber E, passing into opening F, and through valve C, to atmosphere. Modulating valves are used on the radiators. If steam pass through radiators and into return line and into float chamber E, expanding thermostatic float G, closes valve H. If the steam pressure run up to a point high enough to force water up the return line to the trap, water passes into float chamber E, and raises the float G, and closes valve H. When the steam goes down, valve C, is forced to seat by coil spring and vacuum is formed by condensation in the radiators and drawing the vapor through the system until the temperature is too low in heating system to cause circulation. Then when the fire is replenished and steam commences to be given off circulation is again established before any pressure is shown and when pressure rises the tri-duty air and vaccum trap functions as before.

not to mystify the ordinary public, their customers would no doubt be more enlightened and more numerous.

The term *vapor* as used, simply means **steam** *at approximately atmospheric pressure.*

Low pressure steam, vapor, and vacuum, as applied to heating, are merely relative terms, the first applying to pressures of 1 to 5 pounds; the second to pressures of 1 to 5 ounces, and the last to any pressure below atmospheric.

Fig. 8,438 shows an atmospheric pressure, heating system.

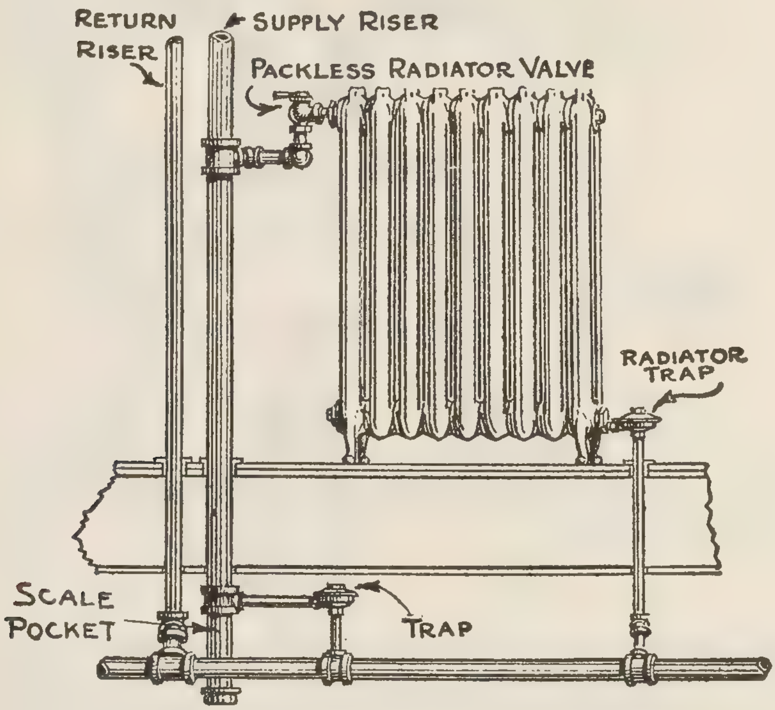
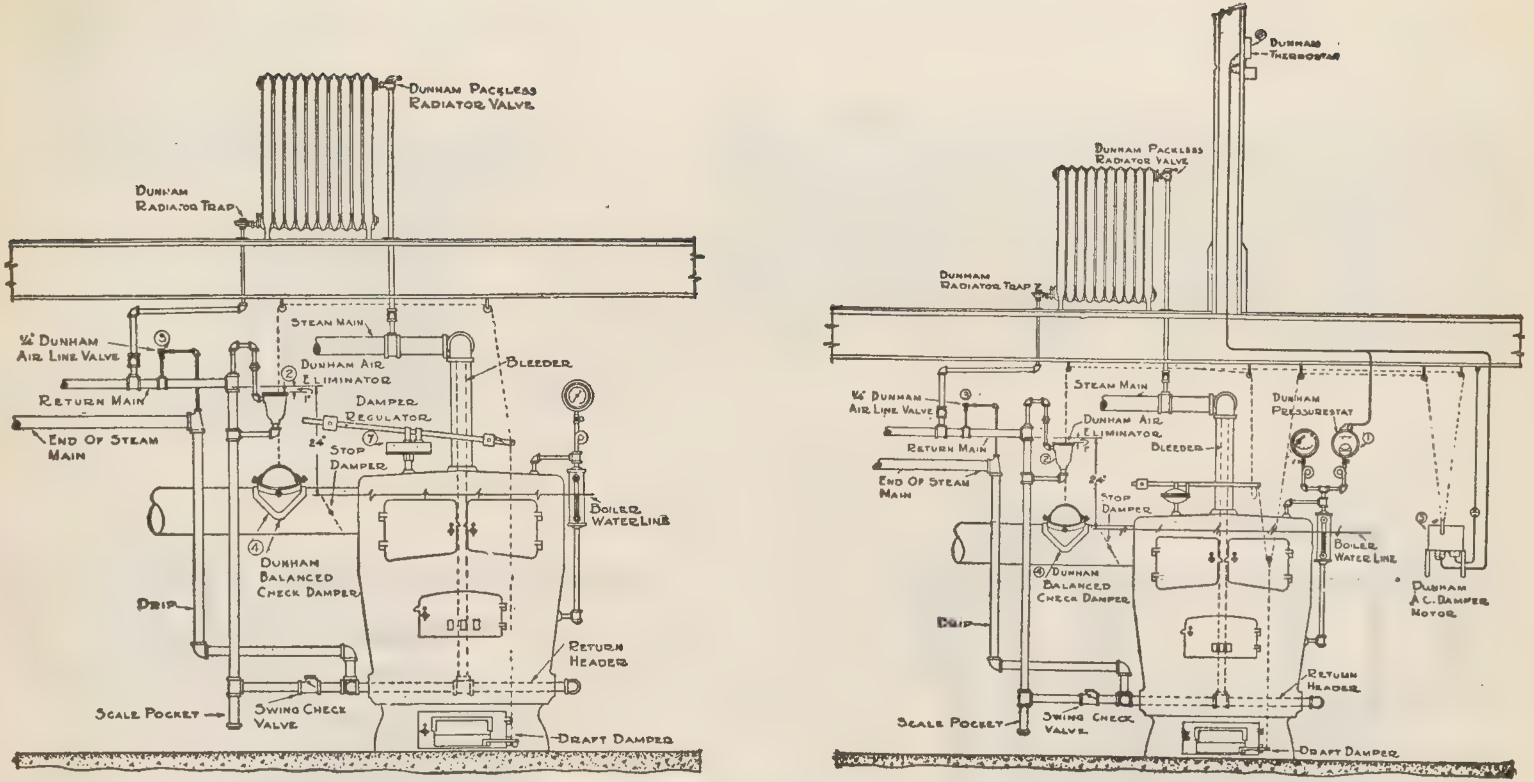
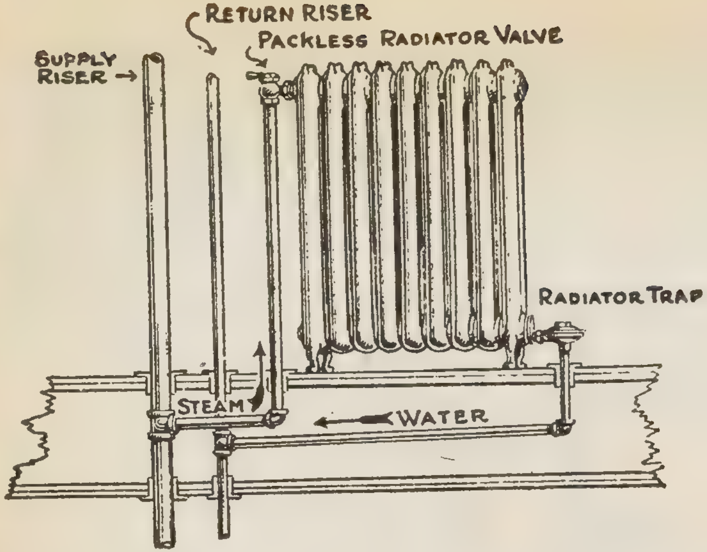


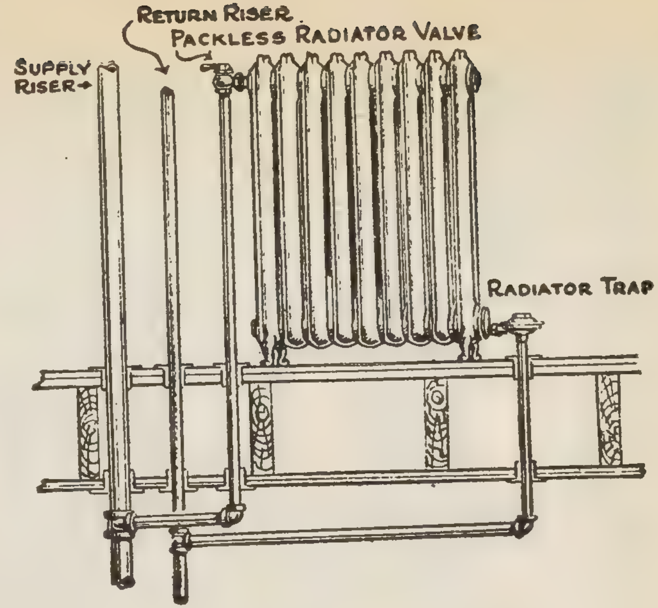
FIG. 8,447.—Dunham piping suggestions for radiator connections, radiator trap and traps used to drip a down fed riser.

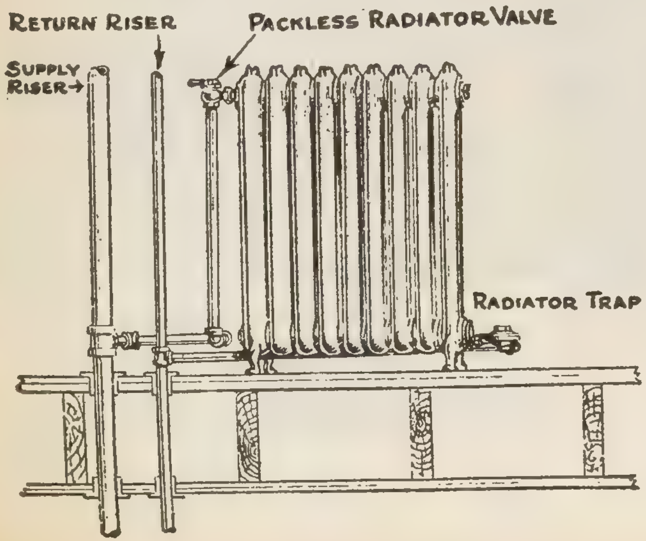
It should be understood that the term atmospheric pressure is only used for convenience, for in fact a pressure of about five ounces above atmospheric is carried on the boiler or sufficient to overcome the frictional resistance of the piping, and since the return connection of the radiators is open to the atmosphere, it can be readily understood that the success of the system depends on the proper working of the automatic damper regulator in keeping the boiler pressure within proper limits. To accomplish



FIGS. 8,448 and 8,449.—Dunham damper regulation. The steam pressure is very low, not over 8 ounces or so called *atmospheric*. Fig. 8,448 shows the diaphragm type regulator. ***In operation,*** the pressure within the boiler acts directly on the large diaphragm causing it to expand or contract as the pressure increases or decreases, and the draught and check dampers are closed or opened as required. Fig. 8,449 shows an electric damper regulator sometimes used in place of the diaphragm type. The electric regulator consists of a "pressurestat," a thermostat, and a damper motor. The motor may be of three types—spring, *d.c.*, or *a.c.* electric motor. The pressurestat is located at the boiler, its function is to control the steam pressure, operating the damper motor as, occasion requires, to make it move the draught and check dampers. The thermostat which is operated by the temperature of the room in which it is located controls the draught in conjunction with the pressurestat through the damper motor. Only one thermostat and pressurestat can be used with one heating plant.







FIGS. 8,450 to 8,452.—Dunham atmospheric system piping methods. Fig. 8,450, pipes between floor and ceiling; fig. 8,451, pipes below ceiling; fig. 8,452, pipes above floor. Angle pattern traps with suitable connection are preferable although the Dunham Trap can be supplied in the corner and straightway patterns when necessary. Hot water type radiation with top inlet tapping is recommended. It is of importance in applying Dunham Traps to their several uses to properly grade the units or piping to be dripped toward the trap and the return piping away from the trap. All piping must be free from sags or pockets.

this the dampers are controlled by a float working in a float chamber in communication with the water space in the boiler as shown.

When the pressure in the boiler is the same as that of the atmosphere, that is, zero gauge pressure, the water level in the float chamber is the same as that in the boiler and the index hand points to zero.

Now in generating steam as the pressure increases, the water level in the boiler is forced downward, which causes the level in the float chamber

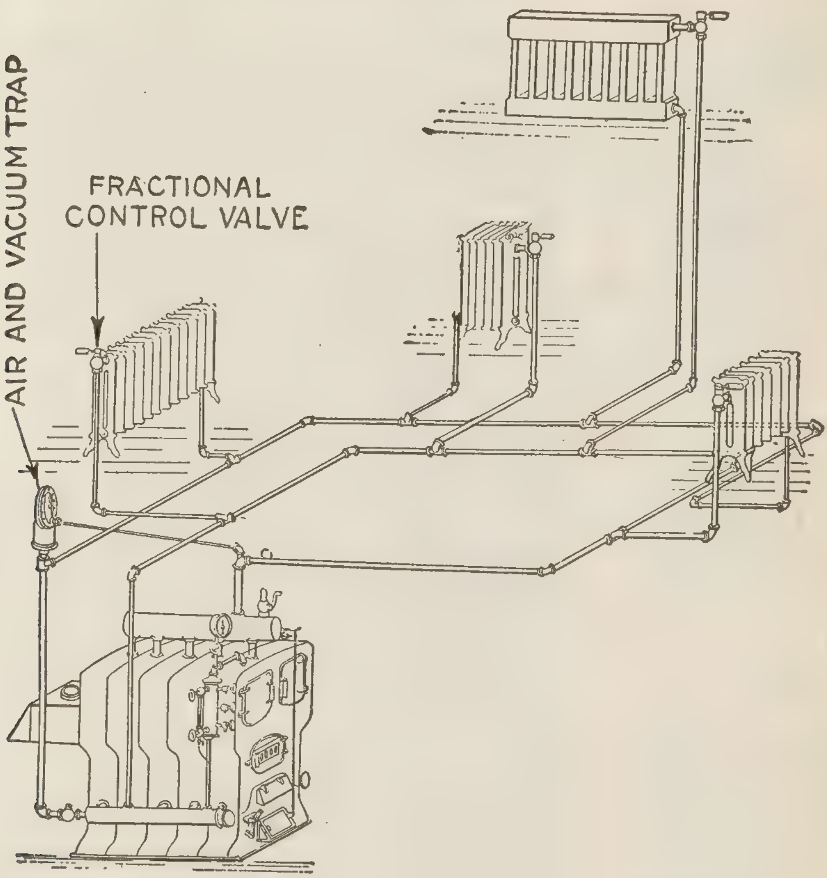


FIG. 8,453.—Imico combined atmospheric pressure and vacuum system showing proper method of installing the Dewey tri-duty air and vacuum trap.

to rise until the pressure due to the difference AB, of water levels balances that in the boiler.

The float in rising, since it is connected by pulleys and chains to the dampers, closes the ash pit damper and opens the stack damper, thus checking the draught and preventing the further increase of steam pressure. Steam is distributed to the radiators through the usual risers, which, however, with this system are connected to the radiators at the top as shown in the

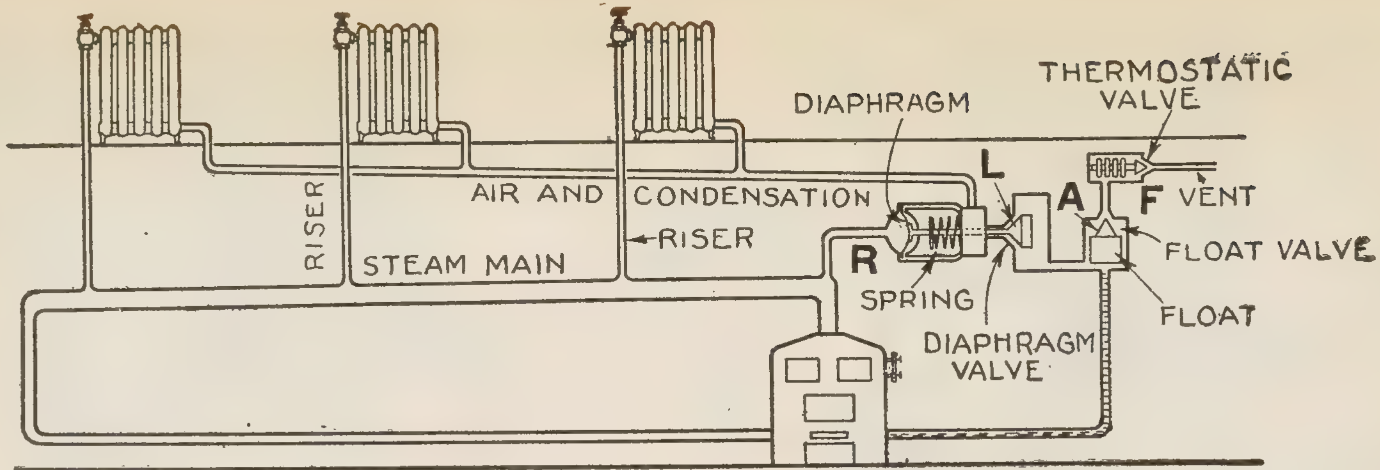


FIG. 8,454.—Combined atmospheric pressure and vacuum. Pressure in the boiler is obtained from one to five ounces above atmospheric pressure, which is needed to operate the diaphragm regulator until air is expelled and the complete system filled, it being then "throttled" by the radiator supply valves while giving the desired vacuum in the radiators. ***In operation,*** when steam is raised in the boiler it passes through the steam main, risers and supply valves to the radiators. The proper working of the system is obtained by an automatic device or trap which closes against the pressures of either steam or water and allows air to pass out, but not return. This device, as shown, consists of three elements: diaphragm valve **L,** float valve **A,** and thermostatic valve **F.** There is a connection **R,** from the supply pipe or pressure side of the boiler to the diaphragm and when there is no pressure in the boiler this valve is held shut by a spring. When the fire is started and the air in the boiler is expanded, the diaphragm is inflated and opens the vacuum valve, making a direct opening through valve **A** and **F,** (which under this condition are also open) to the atmosphere. The valve **L,** remains open as long as there is a fraction of an ounce pressure on the boiler Now, as steam forms and passes through the system it drives all the air out through the three open valves, **L,A,F,** but when the steam on its return from the system reaches the thermostatic valve **F,** the heat causes it to expand and close, thus the system is filled with steam only. The vacuum is now obtained on the principle that the steam admitted into the radiators condenses, while transmitting its heat through the radiator and shrinks considerably (each cu. ft. of steam being approximately reduced in volume to 1 cu. in.). If by too much throttling of the steam supply to the radiators, the vacuum should become strong enough to draw up water in the return pipe too high, the float rises and closes valve **A,** remaining closed until the water recedes, then it opens allowing valve F, to expel any air that may be in the system and the process repeats itself automatically.

figure, the condensation and air passing off through pipes connected to the *bottom* of the radiator. The reason for this is because steam is *lighter* than air, hence, when admitted it floats on top of the air, thus driving the latter out through the lower connection.

The chief feature of the atmospheric pressure system is that the amount of heat given off by each radiator may be regulated by the steam valve (so called fractional control, modulation valve, etc.). Thus, in fig. 8,438, the valve of radiator C, is opened just a little, which will admit only just enough steam to heat the upper portion of the radiator; the valve of D, is half opened, admitting enough steam to heat a larger portion of the radiator; with valve wide opened on E, the entire radiator is heated.

COMBINED ATMOSPHERIC PRESSURE AND VACUUM SYSTEM

The object sought in vacuum heating is to avoid devitalizing the air by using steam in the radiators at pressures *less* than atmospheric, thus reducing the temperature to which the metal of the radiator is heated. For instance, the temperature of steam at atmospheric pressure is 212° Fahr., and at say 5 pounds absolute pressure, which corresponds to a 19.7-inch vacuum, it is only 162° Fahr.

In the combined atmospheric pressure and vacuum systems, the pressure in the boiler is maintained at from one to five ounces above atmospheric pressure, which is needed to operate the damper regulator, it being "throttled" by the radiator supply valves to give the desired vacuum in the radiators. The working principles of such systems are shown in fig. 8,454.

In operation when steam is raised in the boiler it passes through the steam main, risers and supply valves to the radiators.

The proper working of the system is obtained by an automatic device or trap, which closes against the exit of either steam or water, and allows air to pass out, but not return. This device, as shown in fig. 8,454, consists of three elements: diaphragm valve L, float valve A, and thermostatic valve F. There is a connection R, from the supply pipe or pressure side of the boiler to the diaphragm, and when there is no pressure on the boiler this valve is held shut by a spring.

When the fire is started and the air in the boiler is expanded, the diaphragm is inflated and opens the vacuum valve, making a direct opening through valves A, and F, (which, under this condition are also open) to the atmosphere. The valve L, remains open as long as there is a fraction of an ounce pressure on the boiler.

Now as steam forms and passes through the system it drives all the air out through the three open valves L, A, F, but when the steam reaches the thermostatic valve F, the heat causes it to expand and close, thus the system is filled with steam only.

The vacuum is now obtained on the principle that the steam admitted into the radiators condenses, while transmitting its heat through the radiator and shrinks considerably (each cubic foot of steam being approximately reduced in volume to 1 cubic inch).

If by too much throttling of the steam supply to the radiators, the vacuum should become strong enough to draw up water in the return pipe too high, the float rises and closes valve A, remaining closed until the water recedes, then it opens, allowing valve F, to expel any air that may be in the system.

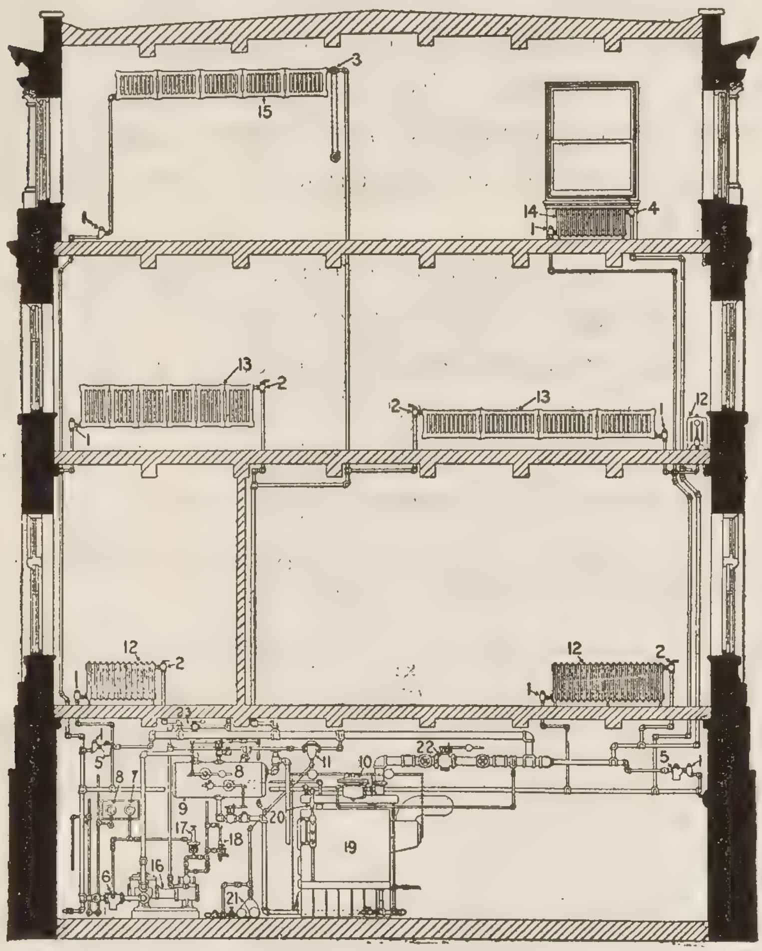


FIG. 8,455.—General arrangement of Webster "Pres-co" vacuum system. ***The parts are: 1,*** syphon trap; 2, modulation valve; 3, modulation valve with chain attachment; 4, modulation valve with extended stem; 5, dirt strainer; 6, suction strainer; 7, vacuum gauge; 8, pressure gauge; 9, hydro-pneumatic tank; 10, damper regulator; 11, oil separator; 12, standard column radiator; 13, wall radiator; 14, window radiator—recessed; 15, overhead wall radiator; 16, vacuum pump; 17, vacuum pump governor; 18, vacuum pump lubricator; 19, boiler; 20, boiler gauge; 21, grease trap; 22, pres-co valve; 23, back pressure valve.

VACUUM SYSTEMS

In order to compete with hot water heating systems which, because of the low working temperature, do not devitalize the air, various steam systems working at pressures below that of

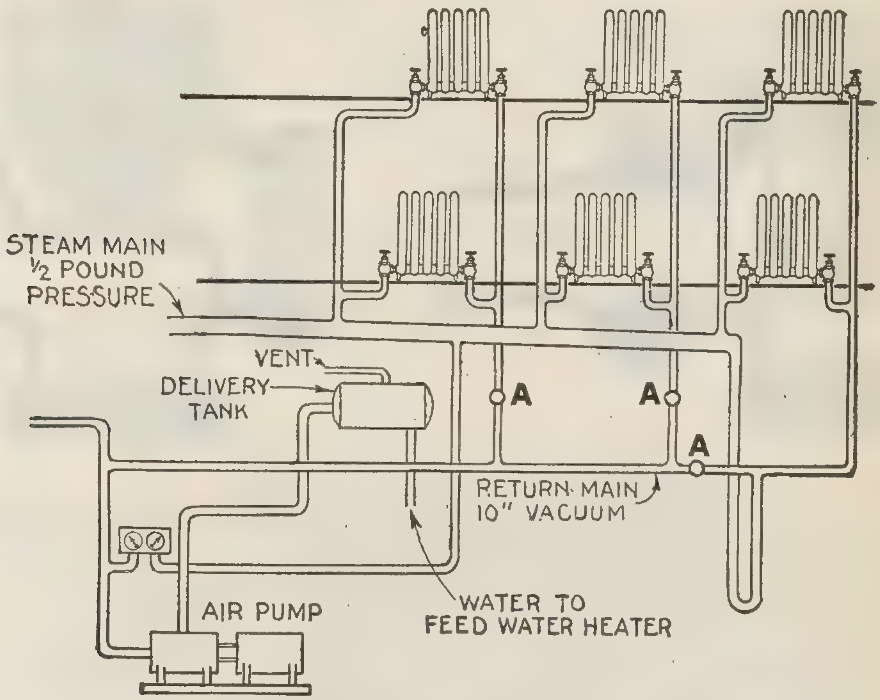


FIG. 8,456.—Differential Co. vacuum return line system showing application of differential and impulse valves. In the installation shown there are three differential valves located in the return risers at A. They are weighted to open at about five lbs. difference in pressure, and as there are a number of radiators in each group, an impulse check valve is placed on the return end of each radiator. ***In operation,*** the vacuum pump is started and the air is exhausted from the return line until a vacuum of 10 inches is produced. This causes the three differential valves in the branch returns to open, and establish a substantially uniform flow through each into the main return. As the air in the pipe between the differential valves and the radiators is exhausted, the impulse check valves on all radiators will open and a uniform flow is thereby obtained from each of these into the branch returns. In accordance with the location of each of the differential check valves, the weights in them are adjusted to compensate for changes in pressure due to the friction of flow in the steam and return mains up to that point, and thereafter no part of the apparatus will require any attention. No jet water is required or necessary at the vacuum pump, and the amount of vacuum carried may be fixed at any point by putting the correct weights in the differential check valves. The degree of vacuum maintained on the return line, or the difference in pressure between the steam and return line, is established and maintained at any predetermined amount by the adjustment of the differential valves. Therefore, a vacuum governor should not be used to regulate the vacuum pump. If the vacuum pump be of sufficient capacity and the main return is tight, the desired vacuum will be maintained by the pump operating at minimum speed.

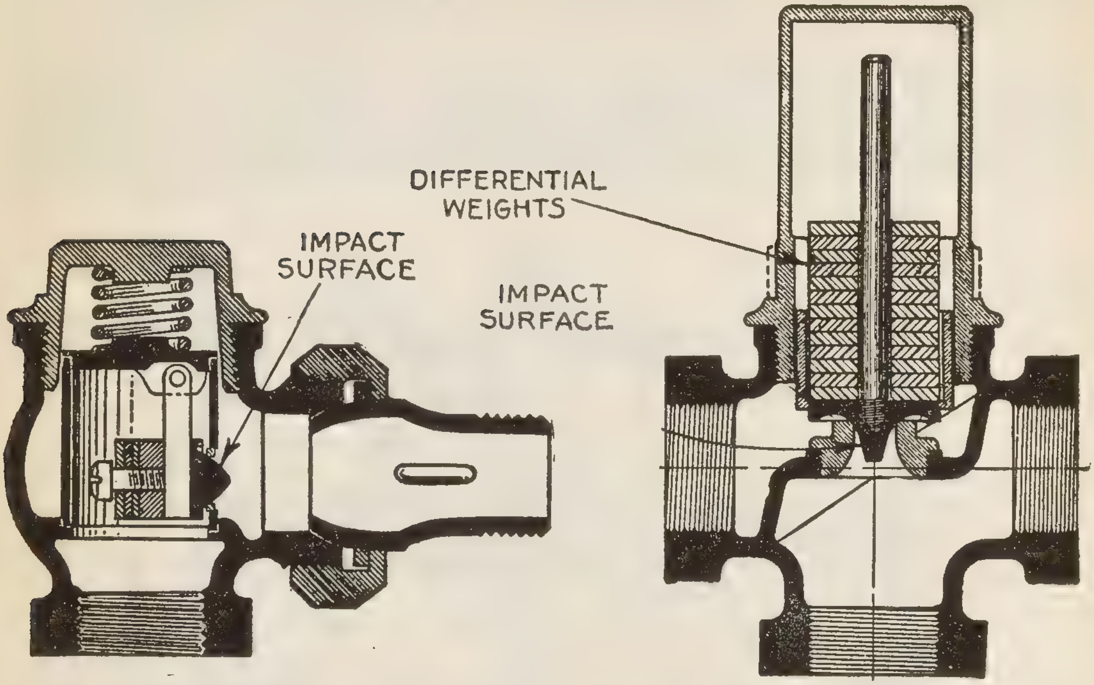
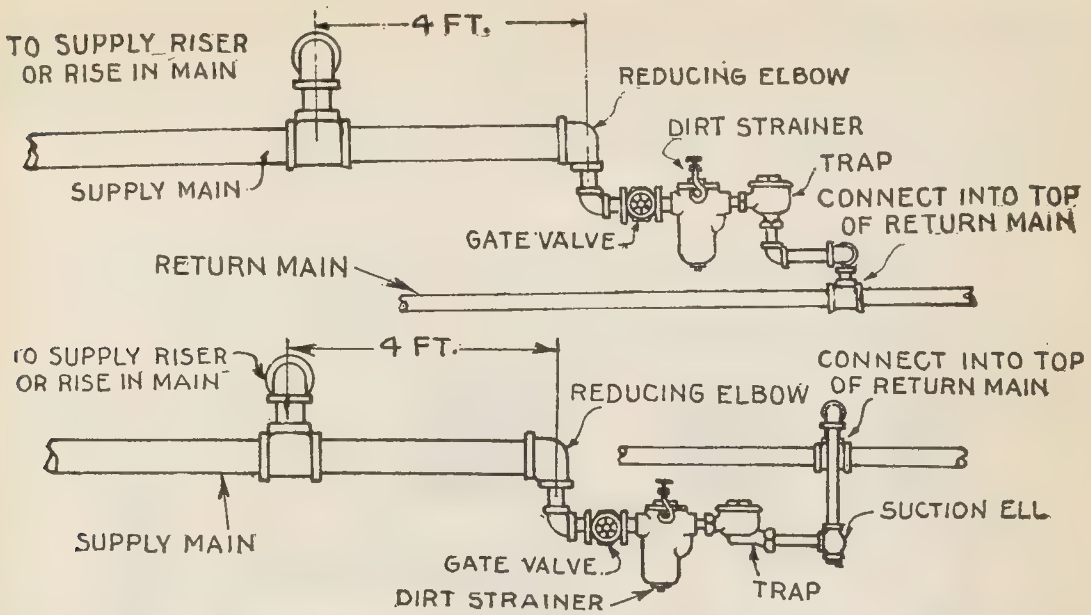


FIG. 8,457.—Differential Co. *impulse* valve for vacuum return line system. ***It consists of*** a heavy brass cylinder inserted in a standard valve body. This cylinder fits into a counterbore which is cut to receive it, and is held firmly in place by a strong spring. A seat is provided in the side of the cylinder, close to the bottom, and a valve disc is swung from above in the same manner as is usual in swing check valves. The valve disc is provided with an impact surface upon which the water of condensation strikes, thereby opening the valve to its full capacity. The seat of the impulse valve is made much smaller than that of an ordinary check valve, so that it will properly control the flow of water and steam from the radiator and prevent short-circuiting. The weight of the impulse valve disc over the area of the seat, as well as the restriction of the orifice, are both so proportioned that the pressure in the branch return lines is from one-quarter to one-half pound lower than the pressure in the steam main, irrespective of the pressure carried. ***In operation,*** when the supply valve of the radiator is closed, the impulse check valve prevents any water or steam entering the radiator from the return.

FIG. 8,458.—Differential Co. *differential* valve for vacuum return line system. ***It is made*** with a standard safety valve body and has a restricted orifice through the seat which is proportioned to the desired capacity of the valve. The valve disc in this, as well as in the impulse valve, is provided with an impact surface upon which the water of condensation strikes in order that the valve shall be opened to its maximum capacity when water is passing. The valve disc is also provided with a central rod and cup shaped portion for holding the weights by which the desired difference in pressure is obtained and regulated. The area of the seats, and the weights in all sizes of valves, are proportioned so that the brass cup will give about three inches of vacuum and each lead weight one inch additional. The opening in the bottom of the valve is intended as a clean out and should be provided with a nipple and cap. All condensation should flow by gravity to the differential check valve, but it may then be lifted to the maximum height permissible by the vacuum carried. A small leakage opening is provided in the seat of the differential valve so that the system will drain when the plant is shut down.



FIGS. 8,459 and 8,460.—Diagrams showing method of connecting Bishop and Babcock vacu-trap on drip points of the return line vacuum system. Fig. 8,459, where return main is below supply main; fig. 8,460, where return is on same level or above supply main.

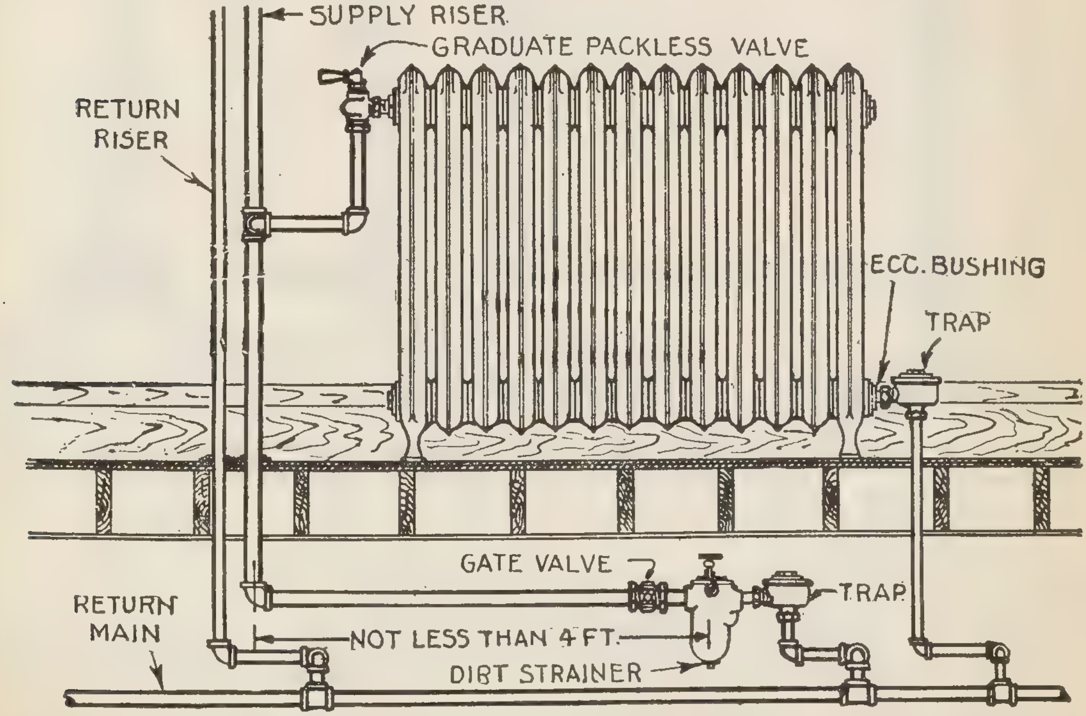


FIG. 8,461.—Typical method of connecting thermostatic valve or so called "vacu-trap" on drip at base of a down feed riser for hot water type radiator as used with Bishop and Babcock return line vacuum system of steam circulation. Drip connection below floor.

the atmosphere have been devised, and are known as vacuum systems. These may be divided into two general classes, according to the method of producing the vacuum, as

1. Natural vacuum, by

   a. Mercury seal.
   b. Thermostatic valves.

2. Mechanical vacuum, by

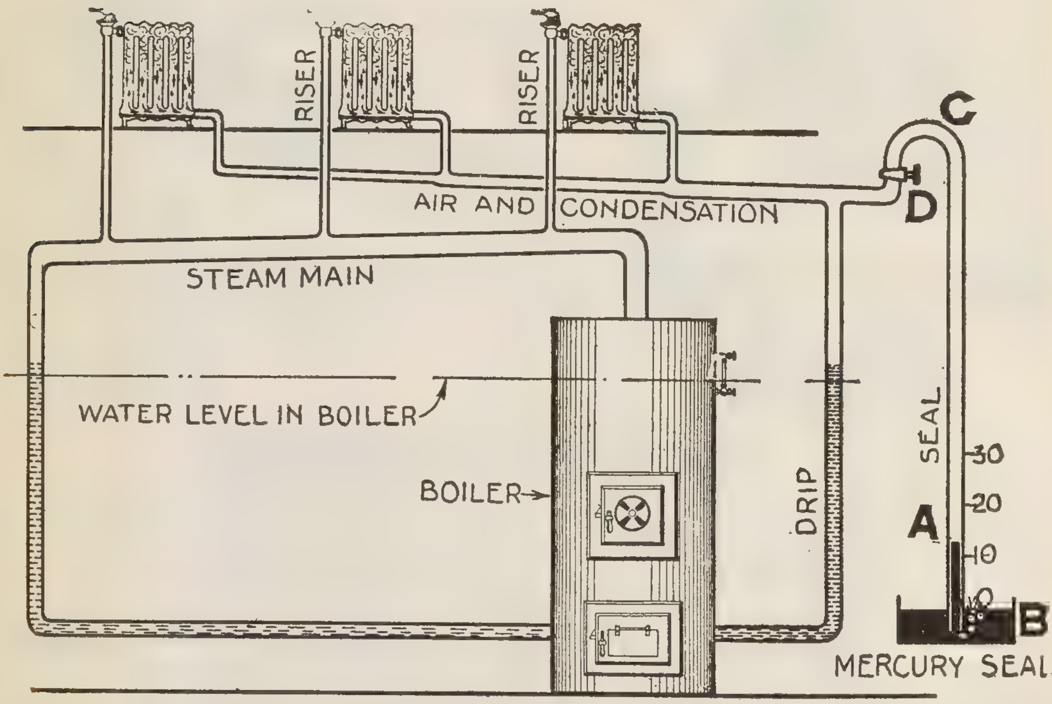


FIG. 8,462.—Natural vacuum mercury seal system. The air line is provided with a valve D, just beyond the drip, and loop C, leading to the mercury seal, the latter being virtually a barometer composed of mercury tube A, and mercury cup B. ***In operation,*** when the pressure is above atmospheric pressure, the air is forced out by bubbling through the mercury in the cup B, and when there is vacuum, the mercury rises in the tube A, to balance the vacuum.

   a. Ejectors.
   b. Air Pumps, etc.

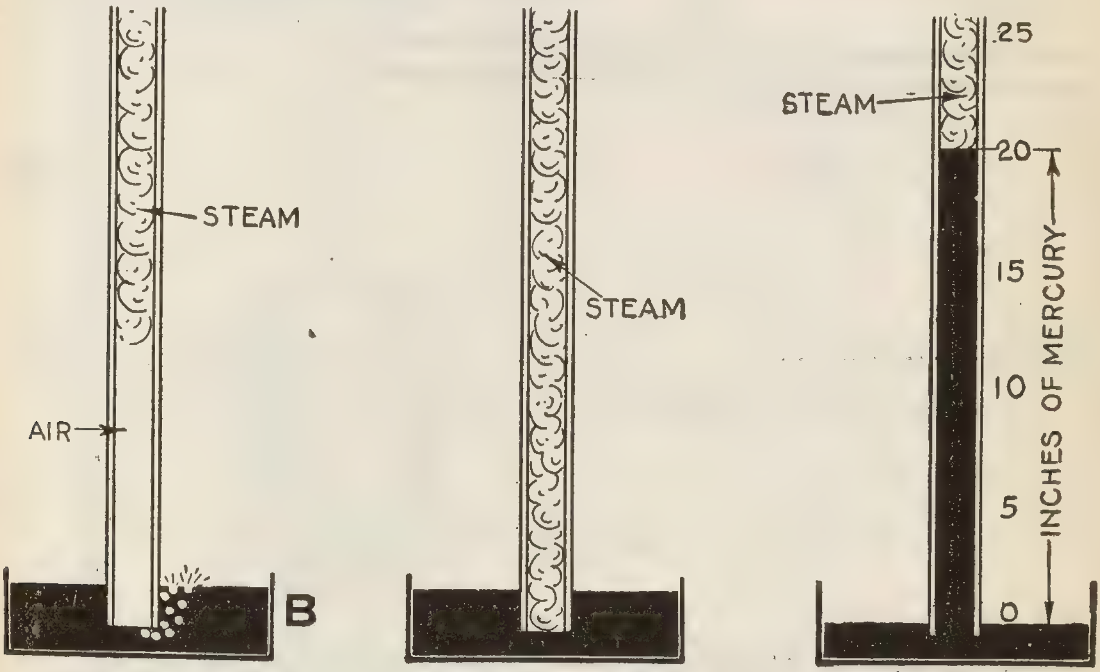
Natural Vacuum Systems.—Any standard one or two pipe steam system may be converted into a natural vacuum system by replacing the ordinary air valve by a "mercury seal" or connecting thermostatic valves to the radiator return outlet on

radiators and providing a damper regulator to the boiler adapted to vacuum working.

The mercury seal system shown in fig. 8,462, is about the simplest arrangement.

The mercury seal, which is virtually a barometer, consists of a tube A, which dips just below the surface of mercury in cup B.

When steam is raised in the boiler to a pressure above atmospheric, it drives all the air out of the system, the air leaving by bubbling through the mercury in cup B. If the fire be then allowed to go out, the steam will condense and produce an almost perfect vacuum, provided all pipe fitting has been carefully done and the stuffing boxes are tightly packed.



FIGS. 8,463 to 8,465.—Operation of mercury seal. Air being heavier than steam, is blown out by bubbling through the mercury in the cup B, fig. 8,463, all the air being expelled in fig. 8,464. Now when the fire is checked the condensation in the radiators produces a vacuum causing the mercury to rise in the seal pipe as in fig. 8,465, to a height corresponding to the degree of vacuum.

Evidently by providing the boiler with proper automatic draught control, the apparatus may be operated at any desired degree of vacuum, say 4 to 5 pounds absolute (21.8 and 19.7 inch vacuum), and have the water boiling at temperatures as low as 153 to 162 degrees F.

A loop at C, prevents water being carried over into the seal pipe when purging the system of air.

If air should re-enter the system through leaks it may be again expelled by raising the steam pressure above atmospheric. As applied to residence

heating, the plant may be operated during the day at several pounds gauge pressure by closing valve D, and when fires are banked for the night this valve may be opened and the system worked under vacuum.

The flexibility of vacuum systems is in sharp contrast with low pressure systems where steam disappears from the radiators as soon as the temperature drops below 212 degrees.

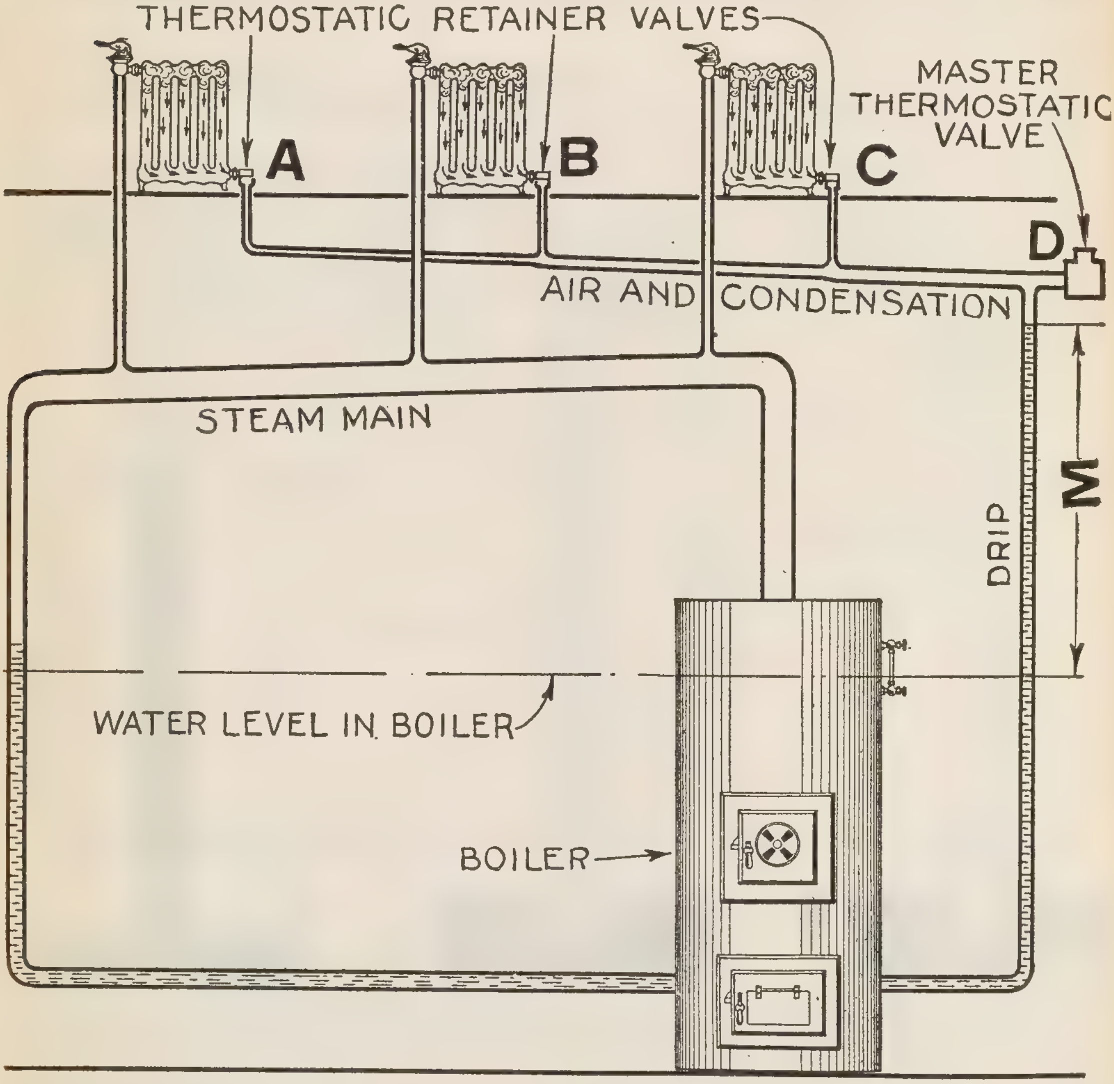


FIG. 8,466.—Natural vacuum system with retainer and master thermostatic valves. Individual thermostatic valves A, B, C, are placed on the outlet of each radiator which pass air or water, but close to steam. At the end of the air line is a master thermostatic valve D, which operates when the system is purged of air by excess pressure. The vertical distance M, between water level in boiler and lowest point of air line should be not less than two feet for each inch of vacuum to be carried in the system.

According to weather demands, the radiators may be kept at any temperature from say 150 degrees to 220 degrees. Figs. 8,463 to 8,465 show in detail the principle of operation of the mercury seal.

Instead of a mercury seal, the same effect may be obtained by the use of thermostatic valves. In the usual arrangements, an

individual thermostatic "retainer" valve is placed on each radiator and a master valve at the end of the air line, as in fig. 8,466.

The object of the retainer valves is to automatically allow the discharge of the air and water without letting the steam pass through; the master thermostatic valve retains the vacuum in the air line.

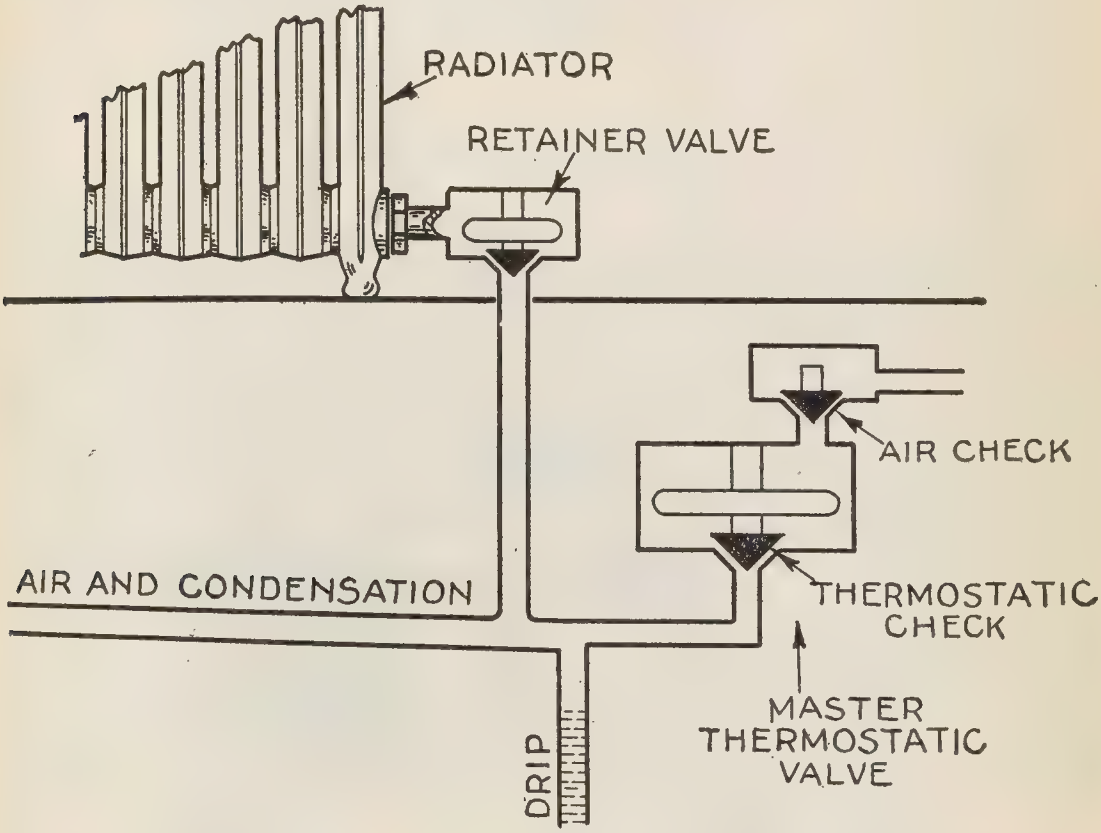


FIG. 8,467.—Detail of natural vacuum system with retainer and master thermostatic valves showing sectional views of the valves. The retainer valves are thermostatic in their action and are used to retain the vacuum in individual radiators. The master thermostatic valve is a purge valve used to clear the system of air and is of the same construction as the retainer valves but has in addition a poppet check valve on top which remains closed as long as the pressure in the system is less than atmospheric.

Fig. 8,467 shows in detail one of the retainer valves and the master valve. The latter has in addition to the expanding element, a ground seat poppet check at the top that is practically air tight and will retain the vacuum within the system for a considerable time. This valve operates when excess pressure is generated in the boiler to purge the system of air, the check at other times remaining closed.

Draught Control on Natural Vacuum Systems. The successful operation of natural vacuum systems depends largely on

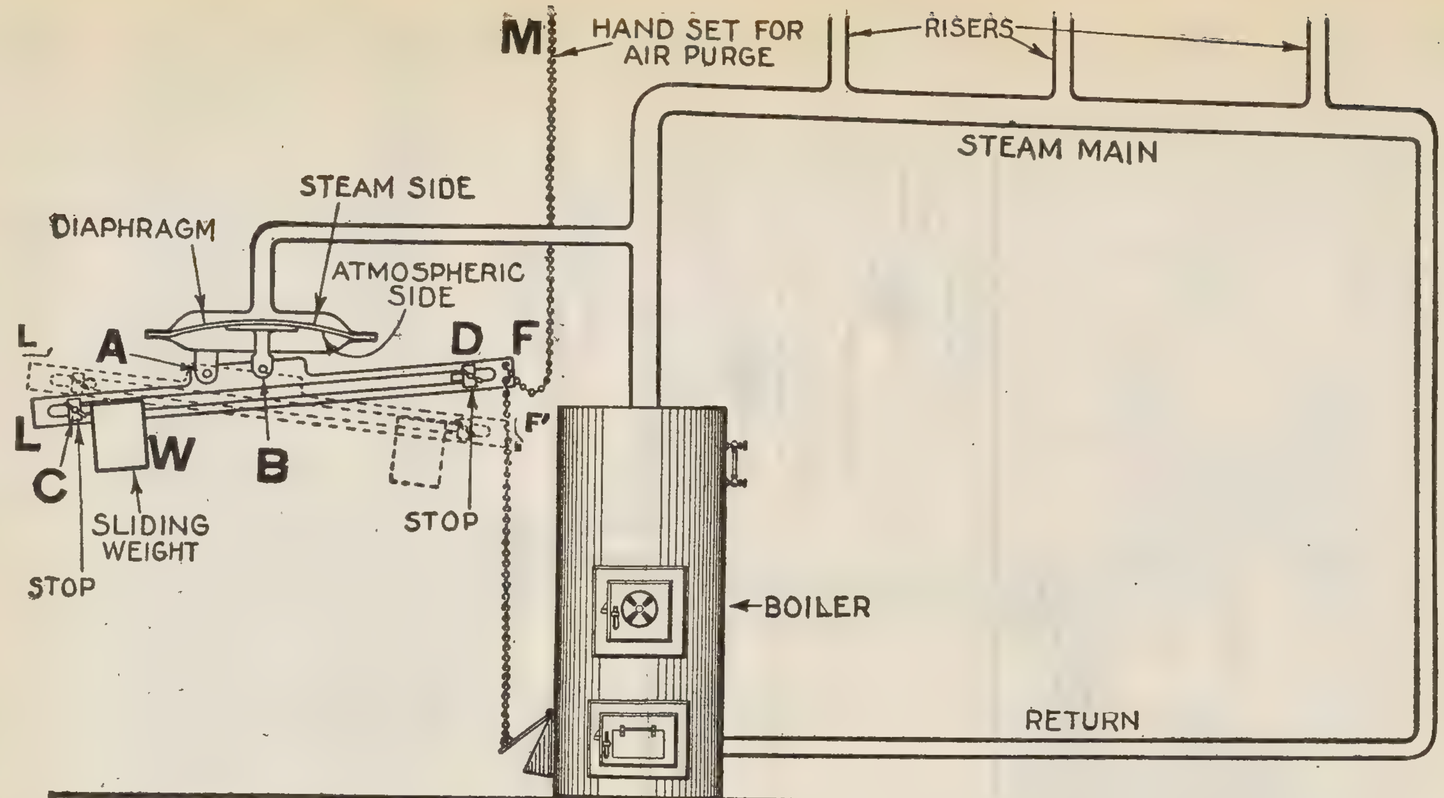


FIG. 8,468.—Damper regulator for natural vacuum system operating on the pressure principle. ***In starting,*** the diaphragm lever is placed in position LF, with weight at left, damper open. When pressure comes on the boiler it trips the lever to dotted line position, L′F′, weight slides over to right, and damper closes. The checking of the fire causes a vacuum to form, and as it increases, the upward pull on the diaphragm (equal to pressure difference on the two sides of the diaphragm) raises the right end F, of the lever and opens the damper, assuming some intermediate position depending upon the position of the weight as regulated by the stop D. That is, to increase vacuum move D, toward F; to decrease, move it toward L.

efficient damper regulators, for unless the fire be held in proper check, the pressure will rise and break the vacuum. Now, this wastes fuel, for there may be sufficient heat in the boiler to supply steam to the system with a five, or even a ten inch vacuum, and

hold that heat in the system for hours. Automatic damper regulators are designed to act by

1. Pressure,
2. Temperature, or

A combination of these two agencies.

Fig. 8,468 shows a regulator which acts on the pressure principle or rather difference of boiler and atmospheric pressure.

It consists of a diaphragm connected at B, to a lever fulcrumed at A, and having a weight W, free to slide along a slot between the stops.

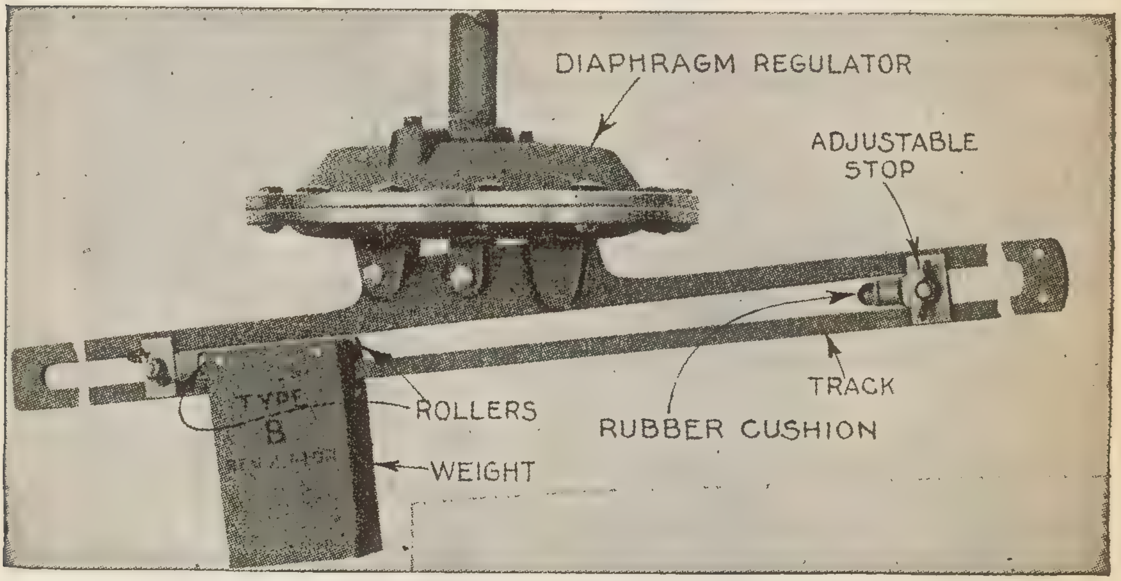


FIG. 8,469.—Roberts-Hamilton type B, diaphragm regulator for natural vacuum system, showing construction of the type shown in the diagram, fig. 8,468.

In starting, the weight is placed on the left side of the lever, as shown, which tilts the lever (position LF), and opens the damper. The weight is adjusted by the stop so that sufficient pressure is produced to clear the system of air before the regulator trips to position L′F′ (shown in dotted lines), and closes the damper.

As the pressure comes on, it will be noted that the regulator is gradually closing, and when entirely closed, the weight slides to the right and remains in this position until the vacuum in the system becomes strong enough to gradually open the damper—just enough to maintain a vacuum.

In the morning the regulator may be set to open position from the floor above by the pull chain M. This generates pressure and purges the system of any air which might have accumulated, and then the regulator weight

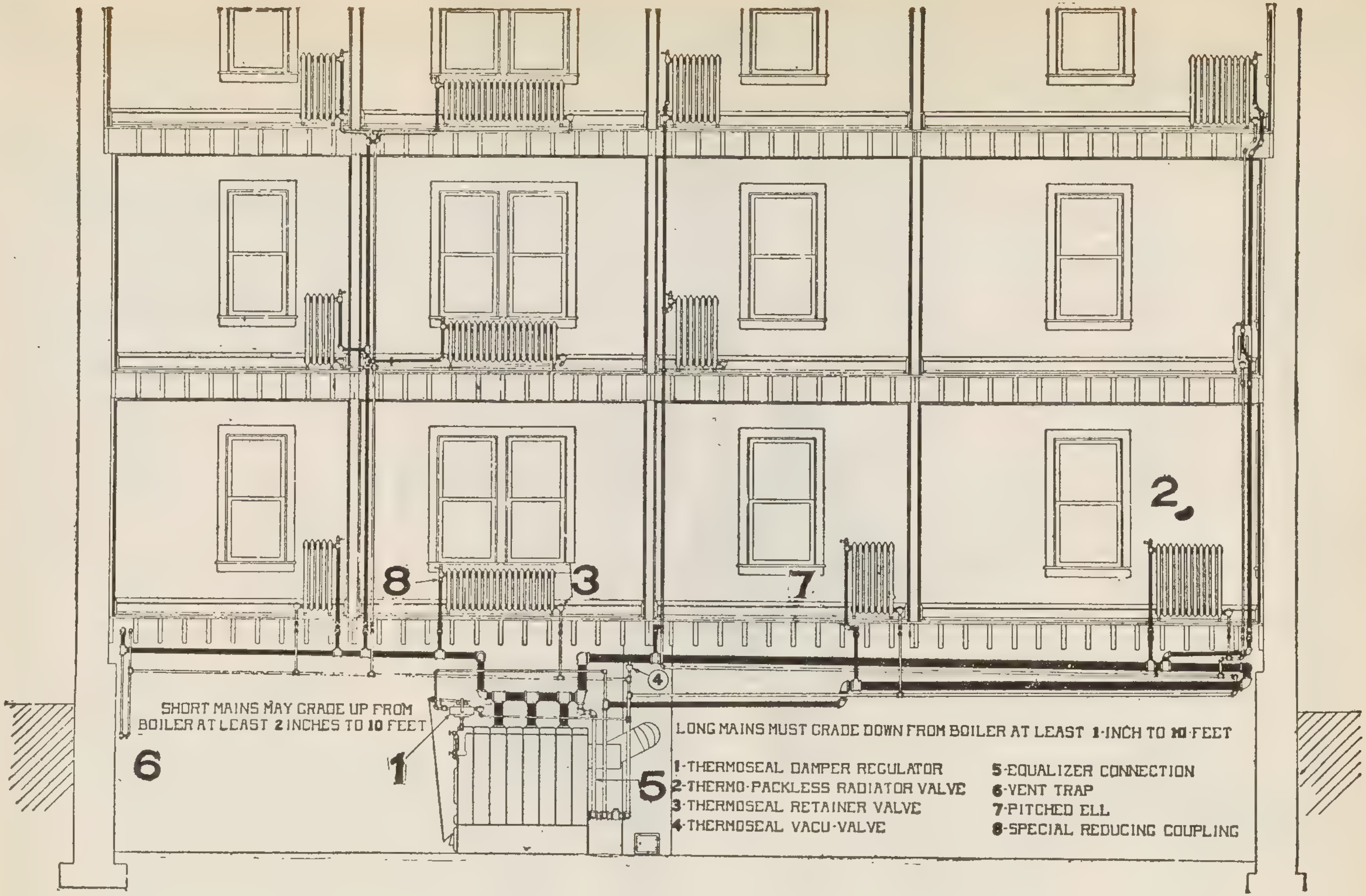


FIG. 8,470.—Roberts-Hamilton "thermo-seal" vapor vacuum heating system.

automatically goes to the vacuum side of the regulator and maintains the vacuum heat until more fuel is required or further regulation necessary.

Fig. 8,471 shows a thermostatic control or damper regulator which depends upon temperature changes for its operation.

Since the temperature of steam increases with the pressure, evidently the expansion and contraction of a rod exposed to the steam can be made to operate the damper.

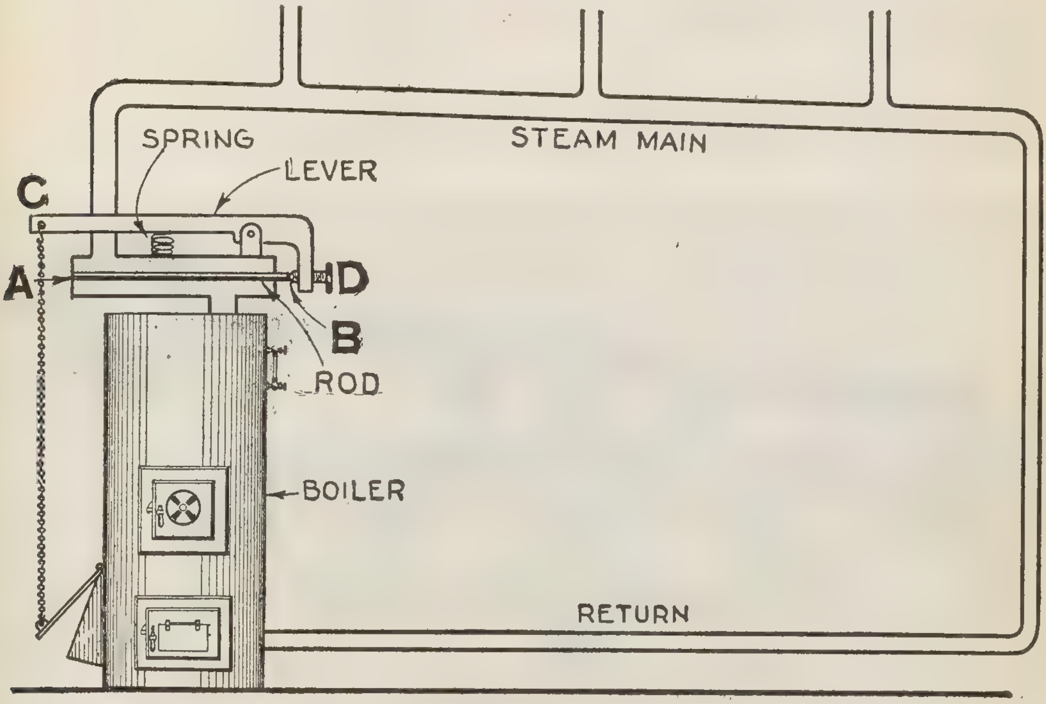


FIG. 8,471.—Thermostatic pressure control or damper regulator operating on changes in temperature of the steam coming from the boiler. The temperature of saturated steam in contact with water depends upon the pressure under which it is generated. At the ordinary atmospheric pressure (14.7 lbs. per sq. in.) its temperature is 212° F. As the pressure of the steam is increased or decreased, its temperature is increased or decreased respectively, thus for a 9.7-in. vacuum, the temperature is 193°; for a 22 in. vacuum, only 153°.

In the figure such a rod is fastened at A, in a closed cylindrical chamber through which steam from the boiler passes to the main. The end B, is free to move, passing out of the chamber through a stuffing box. The motion of the rod is considerably magnified by the bell crank lever, which is connected to the damper by a chain attached at C.

In operation as the pressure of the steam rises its temperature will increase and the rod, which is made of a metal having a higher coefficient of expansion than that of the cylindrical chamber, the end B, will move to the right, thus causing end C, of the lever to descend closing the damper.

When the pressure falls, the rod contracts, and the spring which keeps the bell end in contact with the rod causes end C, of the lever to rise and open the damper.

The lever will assume some intermediate position thus holding the steam at some predetermined pressure, which may be varied by means of the screw adjustment D. In this arrangement, there is no provision for securing excess pressure to purge the system of air at starting; this must be done by hand control of the damper.

A more extended control depends on both pressure and temperature for its operation. Fig. 8,472 shows an arrangement of this kind.

The regulator employs pressure for starting and temperature for running. In starting, the thermostatic portion of the regulator is closed off from the

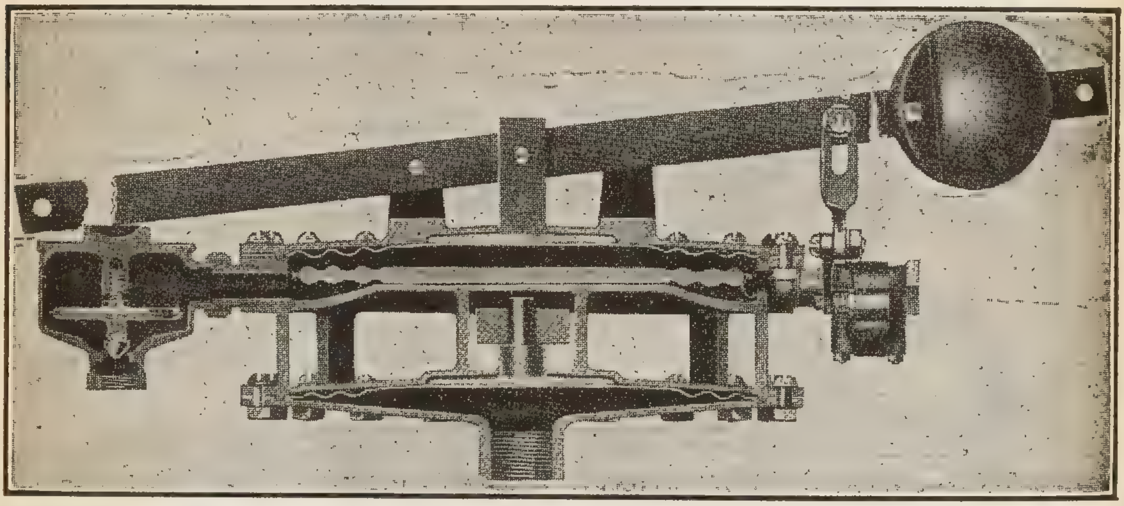


FIG. 8,472.—Roberts-Hamilton pressure-temperature damper regulator. The lower part is the pressure chamber and the upper, the thermostatic chamber. The thermostatic portion of the regulator is connected to the steam main and not to the boiler, so as to regulate the temperature in the radiators and mains. The volatile liquid contained in the double disc of the thermostatic portion is very sensitive and expands and contracts with the slightest change in temperature, so that if it be necessary to increase the temperature within the system, the slight contraction of the discs opens the dampers just enough to produce this temperature and then automatically closes them again.

system, and it is necessary to produce enough pressure (less than one pound) to force the air from the system. When this is accomplished, the regulator automatically opens a valve to the thermostatic portion, which then maintains the temperature desired, its range embracing both vacuum and low pressure operation.

Mechanical Vacuum Systems.—The term *mechanical* is here used to indicate vacuum systems in which an ejector or pump is used to maintain the vacuum, as distinguished from the *natural* vacuum systems already described.

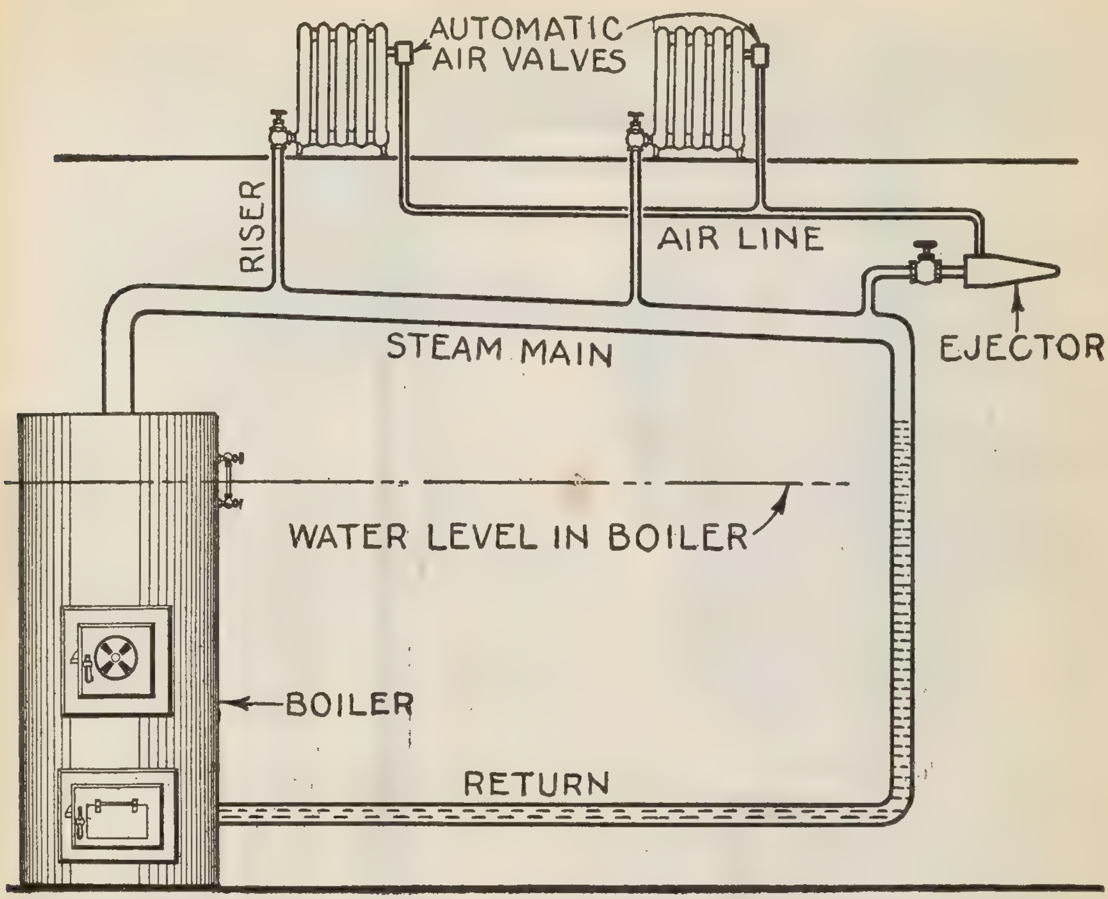


FIG. 8,473.—Ejector mechanical vacuum system as applied to one-pipe distribution. The thermostatic air valves are piped to the air line which has an ejector for ejecting air from the system. The ejector may be operated by live steam or water under pressure. A test made at the Ohio State University showed that 432 lbs. of steam was required for the ejector per 8,160 lbs. of condensation, or approximately 5%. Of course, this steam need not be wasted as it could be utilized in various ways, as, for instance, passing it through a radiator for heating.

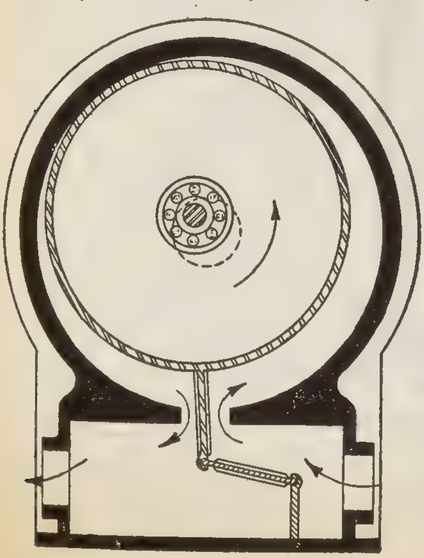


Fig. 8,473 shows an ejector system in which the ejector removes the air only, the condensation returning to boiler by gravity.

FIG. 8,474.—Thompson air line vacuum pump; sectional view showing construction and method of operation. It operates with a rolling motion, but the impeller does not revolve and does not require a water or oil seal.

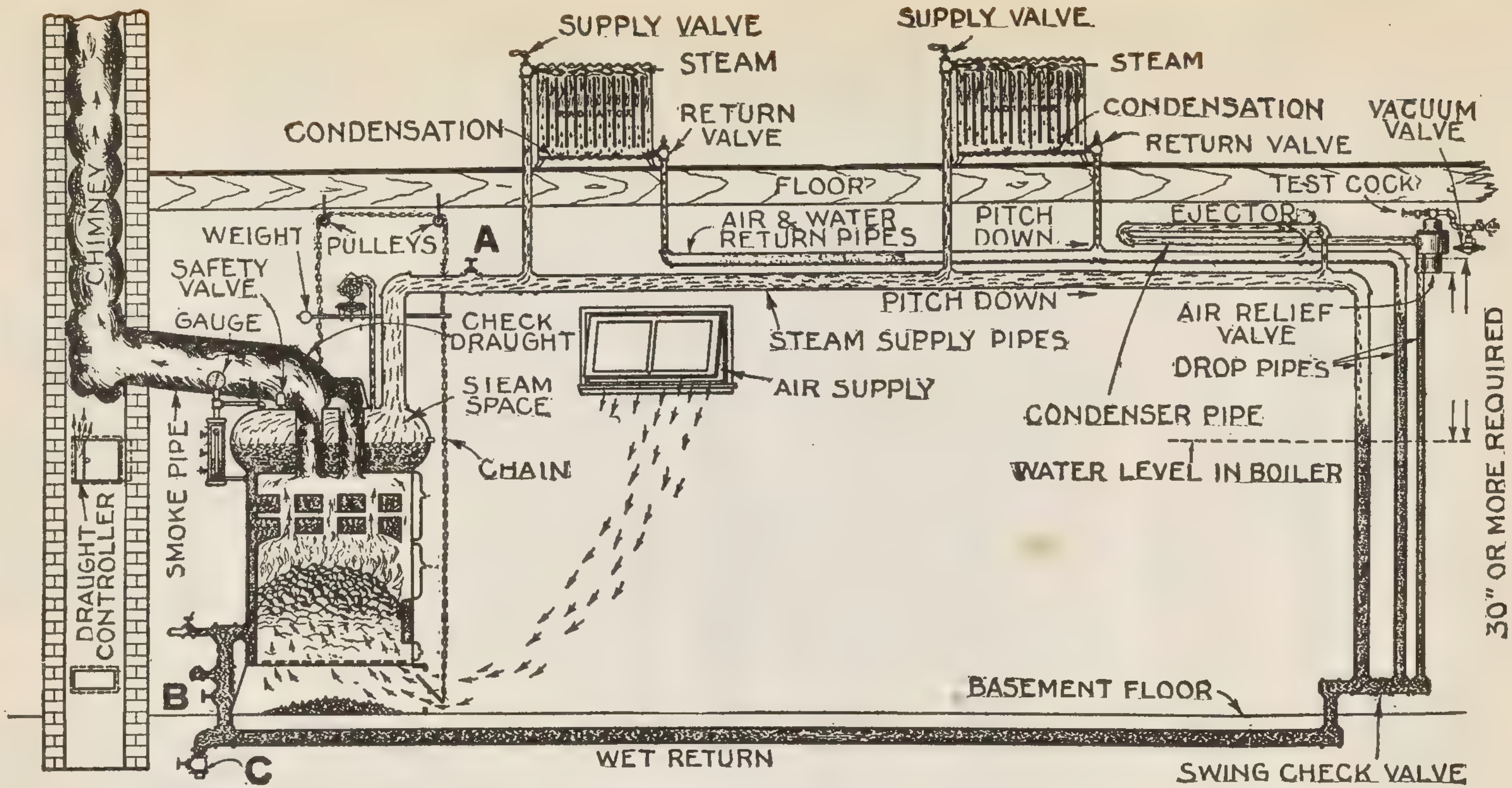


FIG. 8,475.—Sectional view showing construction and operation of Moline mechanical vacuum system. ***In operation,*** the heat expands the air in the boiler and pipes, driving it through the *ejector* at a speed which creates a slight suction on the return pipes. This suction pulls the air out of the return pipes and radiators and through the ejector. The air passes from the ejector into the *condenser* and trom there out into the atmosphere, through an air relief valve. Before all the air is discharged, the water boils and a vapor is generated. This vapor is at first under a few ounces of pressure, and follows the easiest course, filling the supply pipes and radiators before it reaches the return pipes. When all of the radiators are fully heated, the surplus vapor enters the return pipes and passes through the ejector into the small condenser pipe. The condenser pipe acts as a chamber for collecting the mixed air and vapor and protects the air relief equipment. The air valve automatically closes after the air is expelled, being actuated by the heat of the vapor. As the steam condenses a vacuum is formed, the radiators giving off a mild heat.

This system is applicable to either the one pipe or two pipe systems, the figure showing the one pipe arrangement. Thermostatic air valves are placed on each radiator as shown. These air valves being connected by a pipe called the "air line" to the ejector.

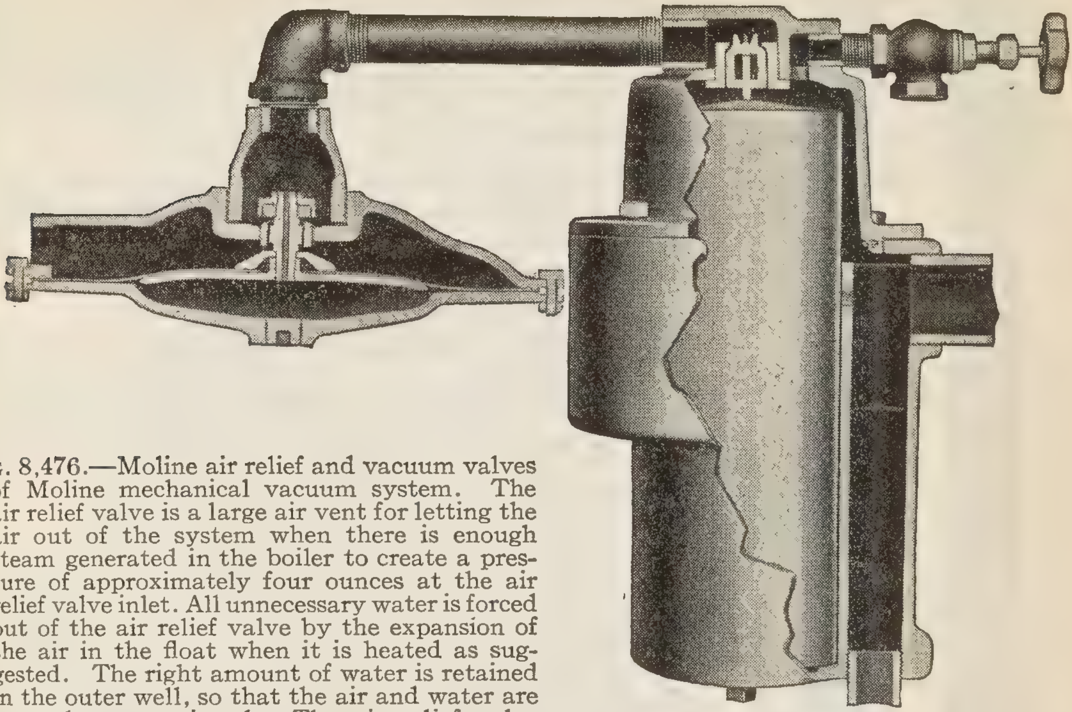
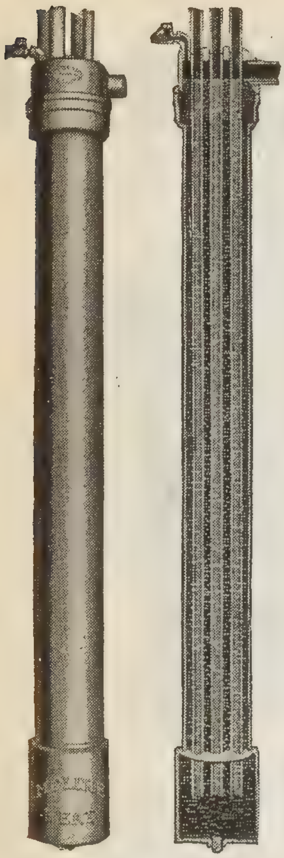


FIG. 8,476.—Moline air relief and vacuum valves of Moline mechanical vacuum system. The air relief valve is a large air vent for letting the air out of the system when there is enough steam generated in the boiler to create a pressure of approximately four ounces at the air relief valve inlet. All unnecessary water is forced out of the air relief valve by the expansion of the air in the float when it is heated as suggested. The right amount of water is retained in the outer well, so that the air and water are properly proportioned. The air relief valve will open when it cools by the air in the float contracting and drawing the water from the well surrounding the float into the float itself, which naturally makes the float heavy and causes it to drop, and the air relief valve is then ready to release the air from the system, when the pressure is again generated in the boiler. When the boiler draughts are opened and steam is again generated fast enough to displace the air in the heating plant, the air will pass out through the air relief equipment automatically until the steam reaches the air relief valve and expands the air in the float; then the float will again rise and close the valve, preventing the steam escaping. The vacuum valve is used on all work where the steam supply fluctuates. It is used for the purpose of keeping the air from re-entering the system when the steam pressure is permitted to drop below zero, or what is called atmospheric pressure, on gauge. When the steam condenses in the radiators faster than it is being produced at the boiler, a vacuum condition takes place, which lowers the pressure inside of the radiators and pipes to less than atmospheric pressure on the outside. Then the air would get back into the system, through the air relief valve, if it were not for the vacuum valve. This vacuum valve is used on heating plants where the pressure fluctuates; as where the heat is regulated by the boiler draught, or where it is not possible to employ a janitor to keep a steady pressure and give constant attention to the heating plant, such as residences or other small or medium sized buildings where individual boilers are used. On large plants, where high pressure is carried on boilers continuously and this pressure is reduced by means of pressure reducing valves; or in connection with central station heating plants, or exhaust steam plants, where a constant supply of steam is always available, there is no need of using the vacuum valve because the production of the steam is always greater than the condensation in the radiators, if the plant be properly designed and installed. In such cases a screen is used at the outlet of the air relief valve instead of the vacuum valve as shown in the illustration above. The vacuum valve operates on the differential principle, using the pressure on the area of a very large diaphragm, to close a valve having a much smaller area. The large diaphragm drops of its own weight, holding the valve open, under normal conditions, or when the pressure in the system, is lower than the atmosphere. The space below the diaphragm is open to the atmosphere. When the steam in the radiators condenses, thereby lowering the pressure in the system or in other words, creating a vacuum, the higher atmospheric pressure is exerted on the lower side of the diaphragm, closing the valve seat. The more vacuum created, the tighter this valve closes.



The ejector, which may be operated either by steam or water, is started before steam is turned on the system, thus, after the air is removed, steam will quickly fill the radiators and remain full of steam since the air is automatically removed as rapidly as it accumulates.

The system is equally well adapted to exhaust heating, where the water flows to a return tank and is pumped back to the boilers, and is largely used in this class of work.

The system commonly used in exhaust heating employs an *air* or so called vacuum pump, which ejects both the air and condensation from the system, such type of air pump being

FIGS. 8,477 and 8,478.—Moline anti-syphon seal for separating the water from the steam or low pressure combined steam traps. These seals will hold back about 3 lbs. pressure in the lines to be drained. They prevent any greater pressure being carried on these lines, and in this way provide against excessive pressures, while giving a range three times the working pressure for the heating mains. The seals are set at the ends of the heating mains. As condensation occurs it flows through the seals. The outlet of the seal is piped to the point of disposal of the condensation, or the receiver of a return trap, steam pump, etc., as conditions demand.

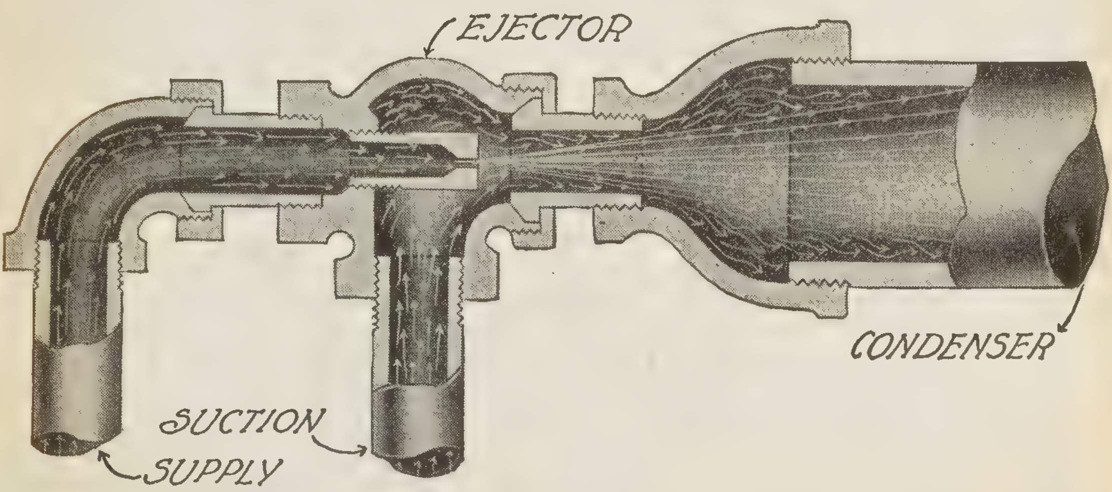


FIG. 8,479.—Moline ejector of Moline mechanical vacuum system. This ejector in connection with a condenser at the end of each main provides for the removal of air from the mains without any dependence on automatic parts.

called a *wet* air pump, as distinguished from a *dry* air pump, which handles only air.

A feed pump is used to return the condensation to the boiler. Fig. 8,480 shows the essential features of the system as applied to the fractional valve distribution. This gives a natural circulation.

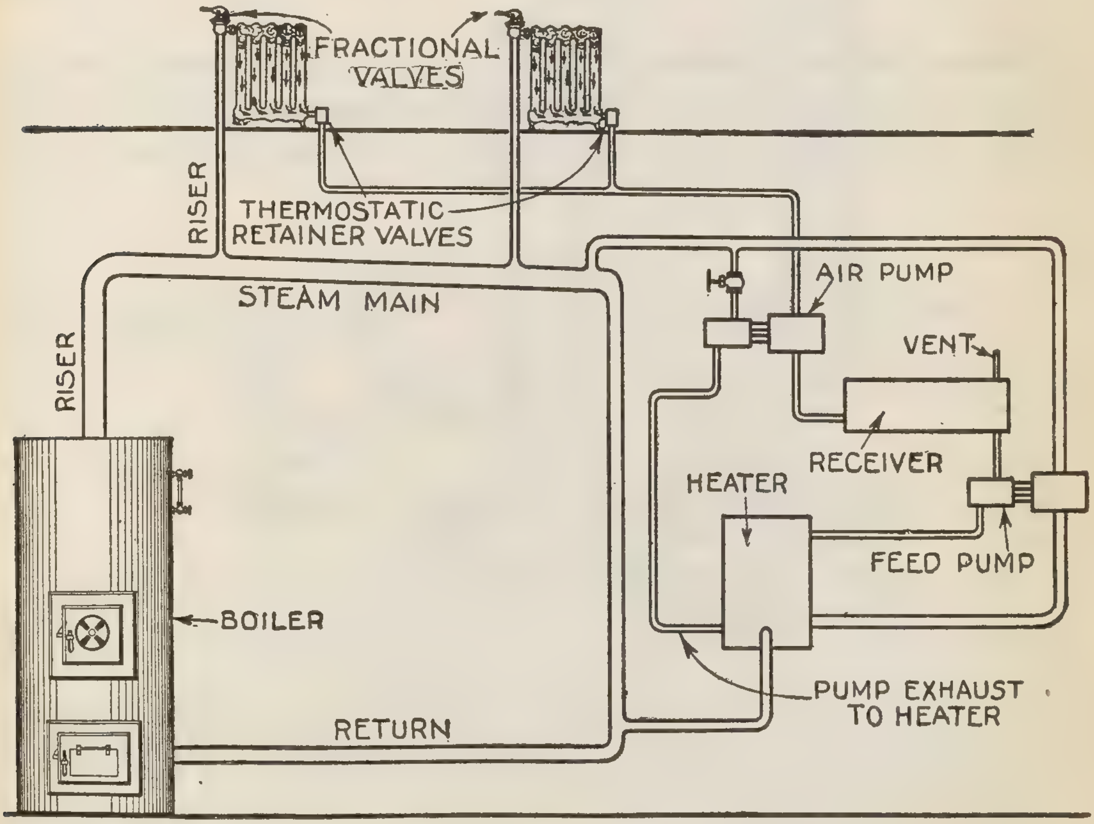


FIG. 8,480.—Air pump mechanical vacuum system as applied to fractional valve distribution. Air pumps are commonly used for maintaining a vacuum on exhaust steam heating systems. The air pump mechanical vacuum system consists essentially of: 1, *thermostatic retainer valves* at the radiators (to prevent steam reaching air pump and breaking vacuum); 2, *receiver* (for discharge from air pump, and having a vent to allow air to pass off); 3, *feed pump*, to pump condensation back through 4, *heater*, to boiler.

In operation, air, being heavier than steam, passes off through thermostatic retainer valves to the air pump. When the steam reaches these valves they close automatically to prevent the steam passing into the return line to air pump and breaking vaccum.

The discharge from the air pump passes into a receiver where the air is allowed to escape through a vent.

The condensation is pumped from the receiver back into the boiler by the feed pump, passing on its way to the boiler, through a heater, where it is heated by the exhaust steam from the air and feed pumps.

Exhaust Steam Heating.—The term exhaust steam heating relates to the *source* of the steam rather than to its distribution. In fact, after the exhaust steam enters the heating system its

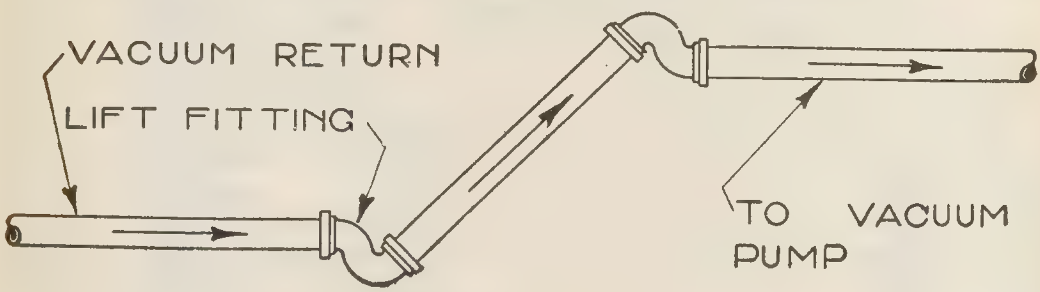


FIG. 8,481.—Lift fittings. The arrangement here shown is adapted for use on the main return lines of vacuum heating systems at points where it is desired tc raise the condensation to a higher level. ***In operation,*** the momentum of the water is maintained and assists in making the lift with a minimum loss of vacuum. The lift fitting is constructed with a pocket at the bottom of the lift into which the water drains. As soon as sufficient water accumulates to seal this pocket it is drawn to the upper portion of the return by the vacuum produced by the pump. The shape of the fitting is such that dirt and scale are usually swept along by the current. Clean out plugs are, however, provided for use, if necessary. A second fitting in a reversed position is recommended for use at the top of the lift (as illustrated) to prevent water running back while the pocket is filling.

action is no different from live steam taken from a heating boiler, it being adapted to both low pressure and vacuum systems. The chief differences are the provision for delivering the steam from the engine to the heating system free from oil and to pressure, and for returning the condensation to the boiler at high pressure.

Fig. 8,483 shows the essential features of an exhaust heating system, with fractional control vacuum distribution. The

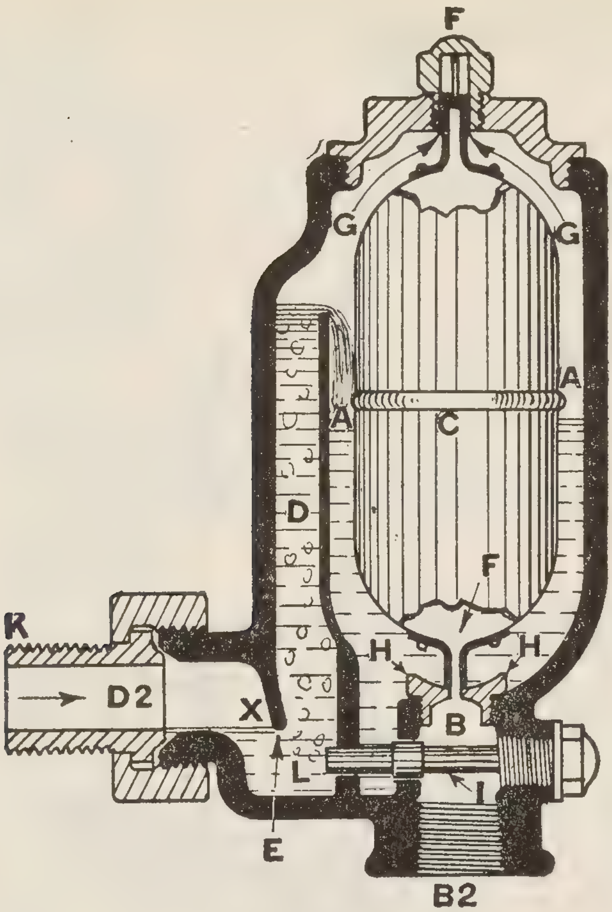


FIG. 8,482.—Sectional view of Van Auken vacuum retainer valve. ***In operation,*** the water of condensation is drawn through passage D and accumulates in pocket L, until it reaches the inverted weir E, it is then drawn upward in space D, until it overflows into the float chamber AA, here it accumulates until the line of floatation is reached. This causes the float C, to lift, opening the valve seat at HH, which allows the water to escape into the vacuum return pipe B2. After the removal of the water the float again settles on seat HH, until sufficient water accumulates in float chamber AA, to again lift the float. The air contained in the radiators or coils, due to condensation, enters through passage FF, and is drawn through the column of water in space D, into the top of float chamber AA. Here its direction follows arrows GG, being drawn through the small opening in guide pin at F, down through the hollow body of copper float, past the valve seat at HH, into the vacuum return B2. This removal of air is continuous regardless of the amount of water present. The by pass I, when opened allows all dirt, core sand or scale to pass directly into the vacuum return thus cleaning the valve and preventing clogging by any foreign substance; the arrangement of by pass is such that the water may be emptied from chamber AA, without interfering with conditions existing in space D. There is no possibility of steam escaping into the vacuum return as the column of water in space D, acts as a water seal, which even in the smallest retainer valve, is three inches deep; also the opening on top of guide at F, is so constructed that steam cannot enter. The pin upon which this travels insures an opening free from foreign matter at all times. The upper and lower guide valve pin are interchangeable, making it immaterial as to how the float is placed in the valve as it works successfully either way. The pin or guide projecting from the cap on top of the valve, keeping the float in proper position. The air outlet being free at all times and the accumulation of foreign matter in the air passage is therefore impossible.

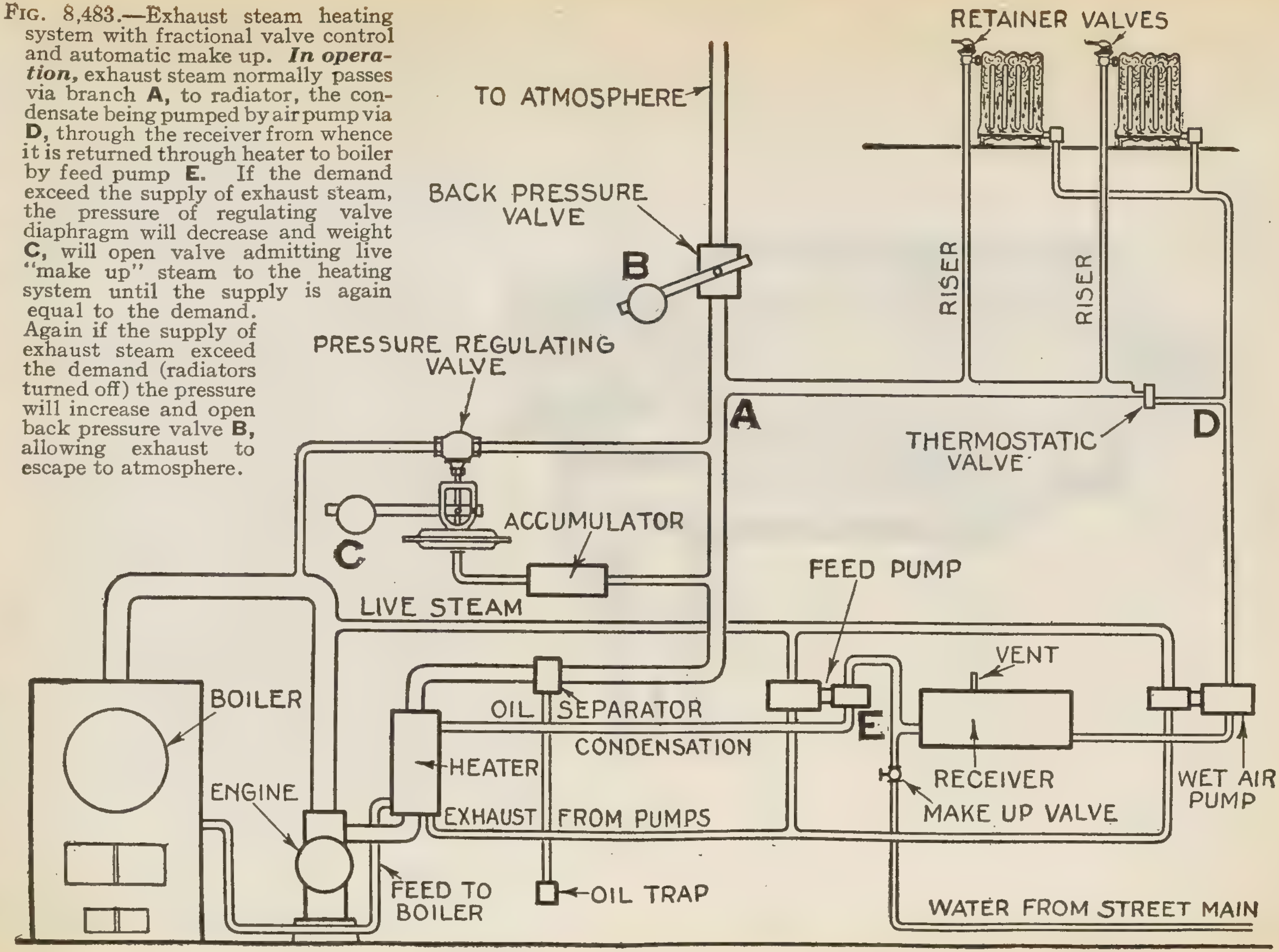


FIG. 8,483.—Exhaust steam heating system with fractional valve control and automatic make up. ***In operation,*** exhaust steam normally passes via branch **A,** to radiator, the condensate being pumped by air pump via **D,** through the receiver from whence it is returned through heater to boiler by feed pump **E.** If the demand exceed the supply of exhaust steam, the pressure of regulating valve diaphragm will decrease and weight **C,** will open valve admitting live "make up" steam to the heating system until the supply is again equal to the demand. Again if the supply of exhaust steam exceed the demand (radiators turned off) the pressure will increase and open back pressure valve **B,** allowing exhaust to escape to atmosphere.

necessary devices between the engine and inlet to heating system are:

1. Oil separator and trap,
2. Back pressure valve,
3. Pressure regulating valve.

and for mechanically producing the vacuum and reducing the condensation to the high pressure power boiler,

1. Air, or so called vacuum pump,
2. Receiver with vent,

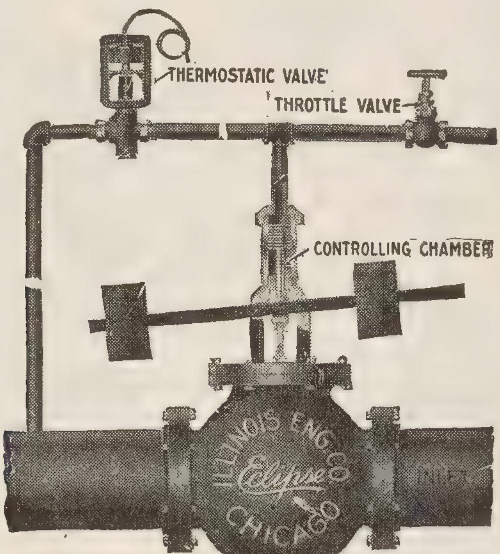


FIG. 8,484.—Illinois "Eclipse" combination temperature regulator. This valve is used to control the temperature of steam, gas, air or water by temperature. It can be arranged to shut off or open as desired with a slight variation of the temperature existing at some desired point.

3. Feed pump,

in addition, a feed water heater is provided both for economy and to permit returning condensation and make up feed water to boiler at the proper temperature. See fig. 8,483.

In operation exhaust steam from the engine first passes through the heater, then through the oil separator, which frees it from the lubricating oil, the latter passing off into the oil trap. The steam now enters the heating system at A, its pressure being prevented rising above a predetermined limit by the back pressure valve (regulated by Weight B), and maintained

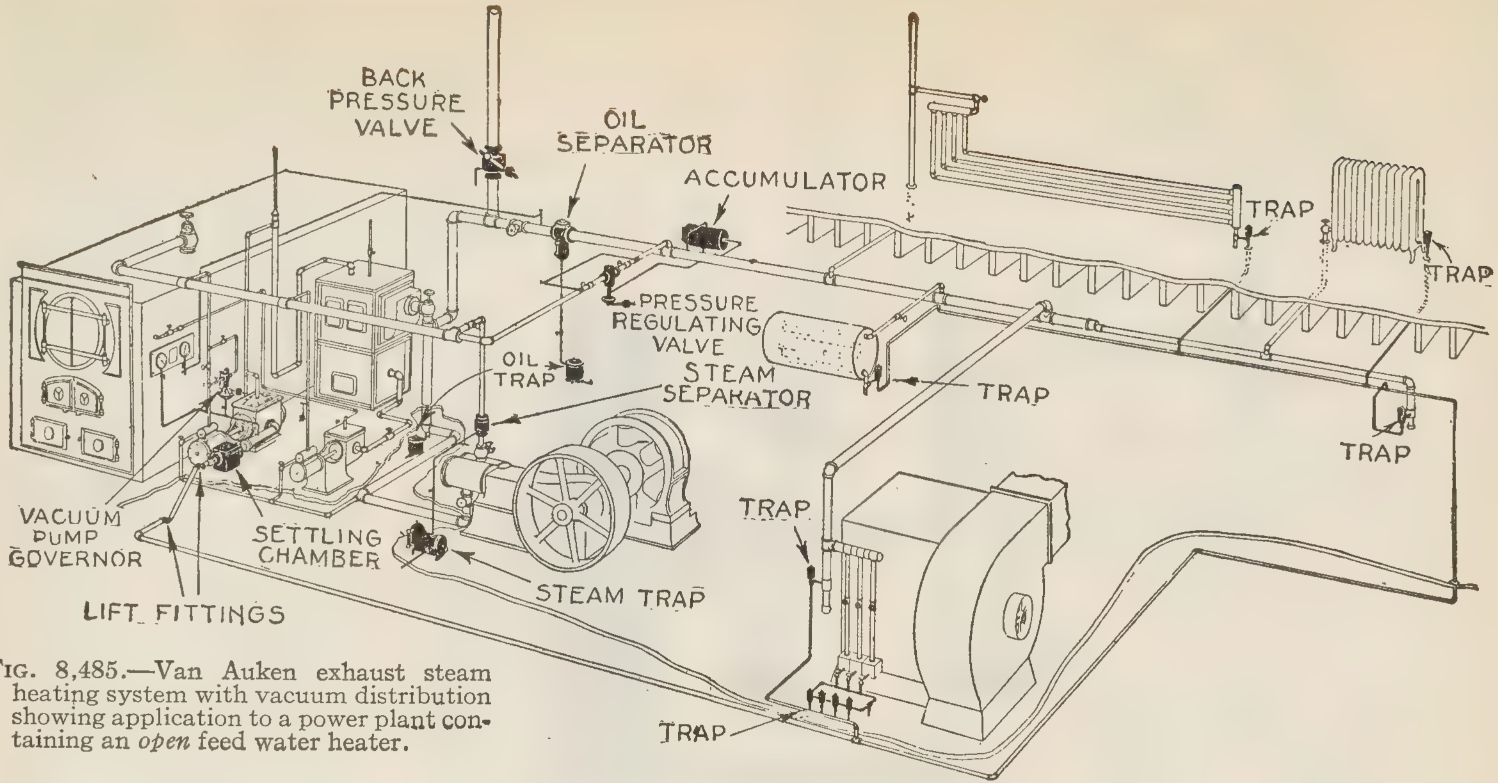


FIG. 8,485.—Van Auken exhaust steam heating system with vacuum distribution showing application to a power plant containing an *open* feed water heater.

at a predetermined constant pressure by the pressure regulating valve (adjusted by weight C). This is in fact an automatic steam "make up" valve which admits live steam to the heating system when the exhaust is not adequate to supply the demand, thus "making up" for this deficiency and maintaining the pressure constant.

The fractional control vacuum system is shown but any other system may be used to suit the conditions.

Condensation and *air* is removed from the heating system at D, by a *wet* air pump (as distinguished from the *dry* type which removes air only). The condensation and air is discharged into a receiver where the air passes off through a vent, the condensation being pumped by a feed pump back into the boiler after passing through a feed water heater.

Since there is a continued loss of water through various leaks, the feed pump suction is connected at E, with the supply from the street main or other source, the amount entering the system being controlled by the "make up" valve.

The various automatic devices, such as back pressure valve, pressure regulating valve, etc., necessary to adapt the exhaust to heating purposes, are shown in the accompanying illustrations.

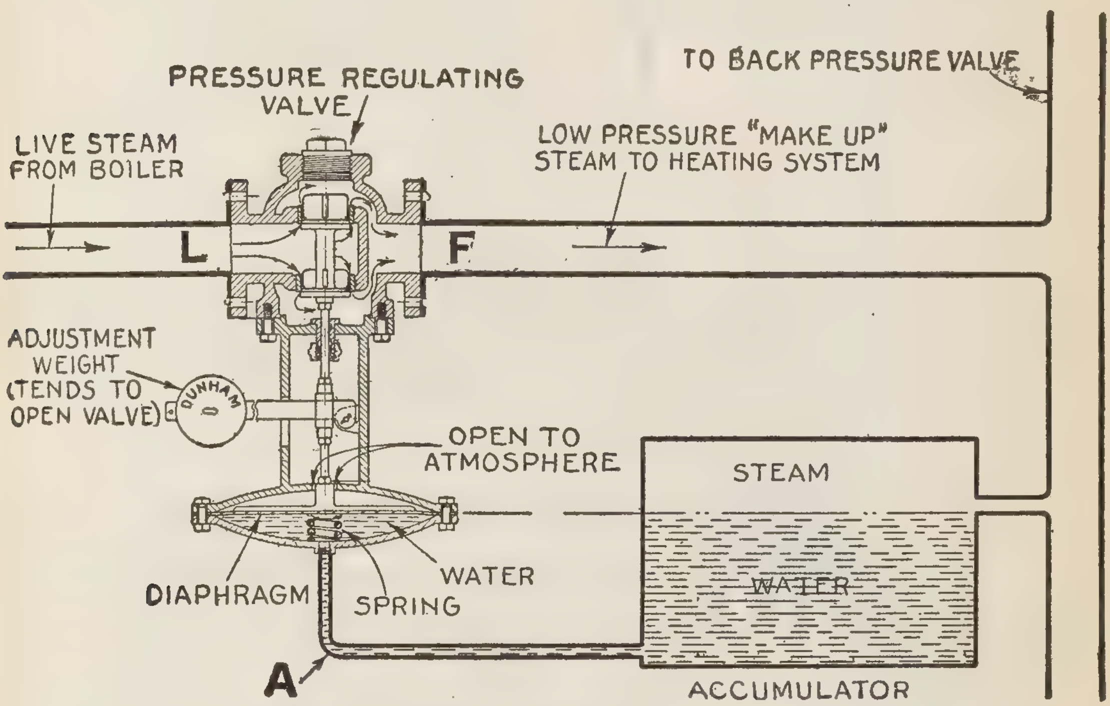


FIG. 8,486.—Pressure regulating valve and accumulator for maintaining a constant pressure in the steam heating main. It maintains the pressure constant by automatically admitting steam when the supply from the exhaust is not adequate to meet the demand, the amount of steam thus admitted being that necessary to prevent fall of pressure. The valve is controlled by means of a governing pipe A, connecting the diaphragm chamber to the accumulator, the latter being connected to the heating main at the point from which the pressure regulator is to be governed. The accumulator is always half full of water and its elevation must be such that the water line in the accumulator is level with the diaphragm, so that there will not be an unbalanced column of water to exert pressure on the diaphragm. The water protects the diaphragm from the steam, the pressure of the latter being transmitted from the surface of the water in the accumulator to the diaphragm. ***In operation,*** when the exhaust side F, is at the predetermined pressure, this brings sufficient force against the under or water side of the diaphragm to overcome the downward thrust due to the adjustment weight and close the valve. Now if the engine slow down, or there be a heavy demand for heat so that the exhaust is not adequate, the pressure in the exhaust side F, will fall, and the downward thrust of the adjustment weight will overcome the opposing pressure of the water on the diaphragm and open the valve admitting live steam from the boiler side L, into the exhaust side F, in sufficient quantity to restore the pressure. The inertia of the water in the accumulator acts as a damper to prevent oversensitiveness of the valve, or "*hunting*," due to slight momentary fluctuations of pressure in the exhaust side F. The spring under the diaphragm is to balance the downward thrust of the lever and hold the valve in closed position when the pressure is the same on both sides of the diaphragm.

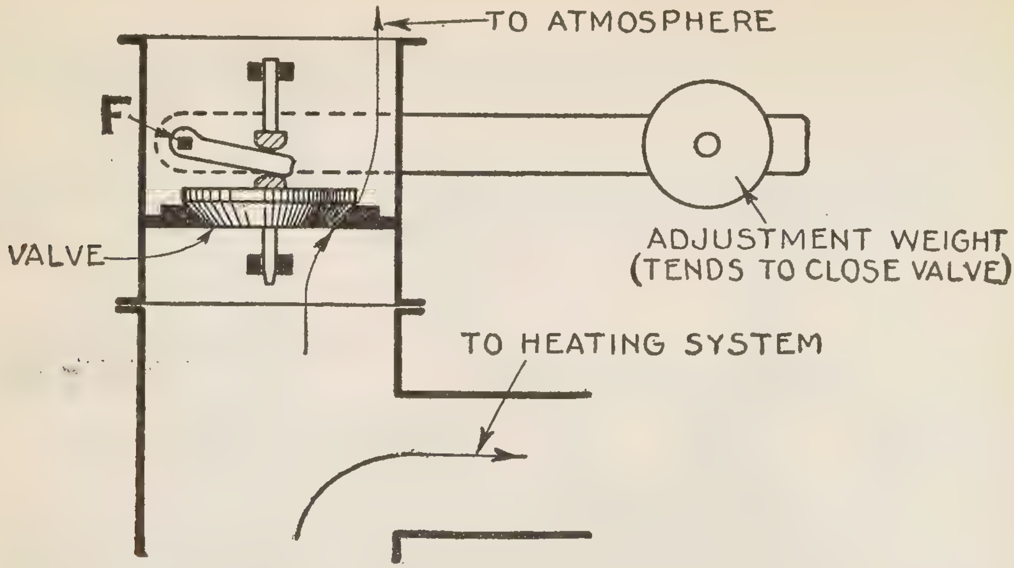


FIG. 8,487.—Back pressure valve to prevent exhaust pressure exceeding a predetermined limit. This is virtually a lever safety valve designed to work at very low pressure. ***In construction,*** some back pressure valves are so sensitive that they will open or close with a variation of only 2 ounces. The position of the weight on the lever which is fulcrumed at F, determines the exhaust pressure at which the valve will open.

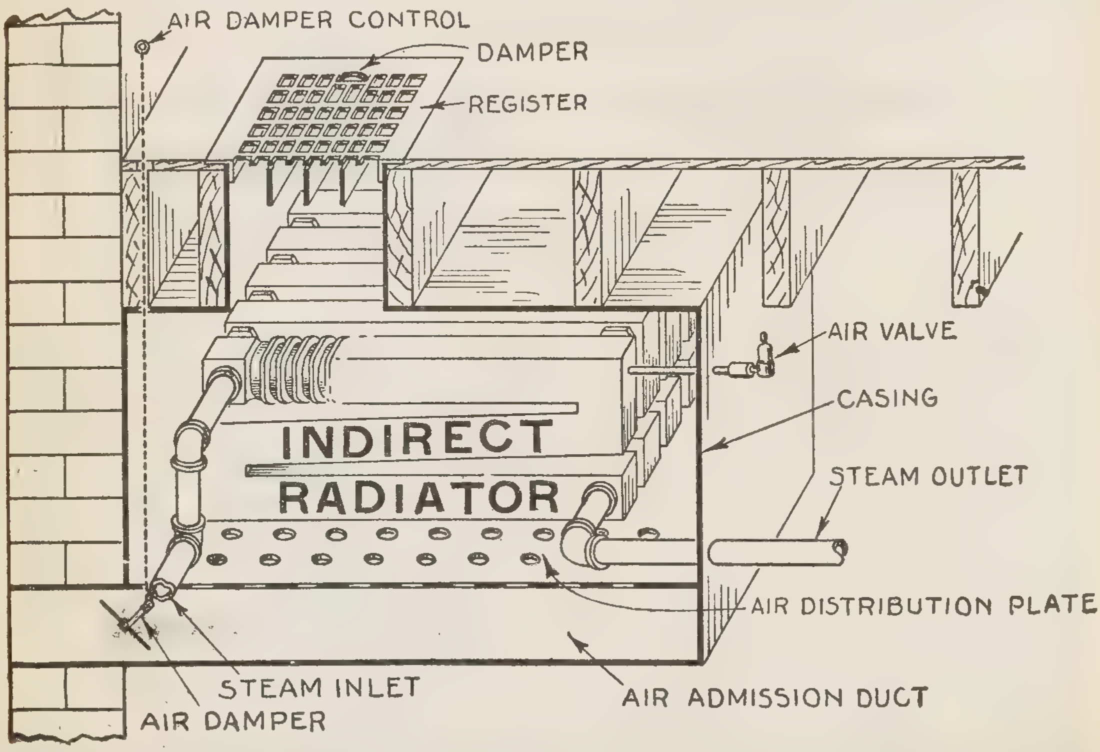


FIG. 8,488.—***Indirect*** heating showing indirect radiator, its placement in air tight casing with duct from outside, distribution plate damper control, and connection with hot air register. The advantage of indirect heating is thorough ventilation, but it is more expensive than direct heating both in installation and in operation.

INDIRECT HEATING

This is a combination of steam or hot water heating and hot air heating, the object of the system being to secure the advantage of steam or hot water as a heating medium and avoid the disadvantages of these or of the hot air furnace.

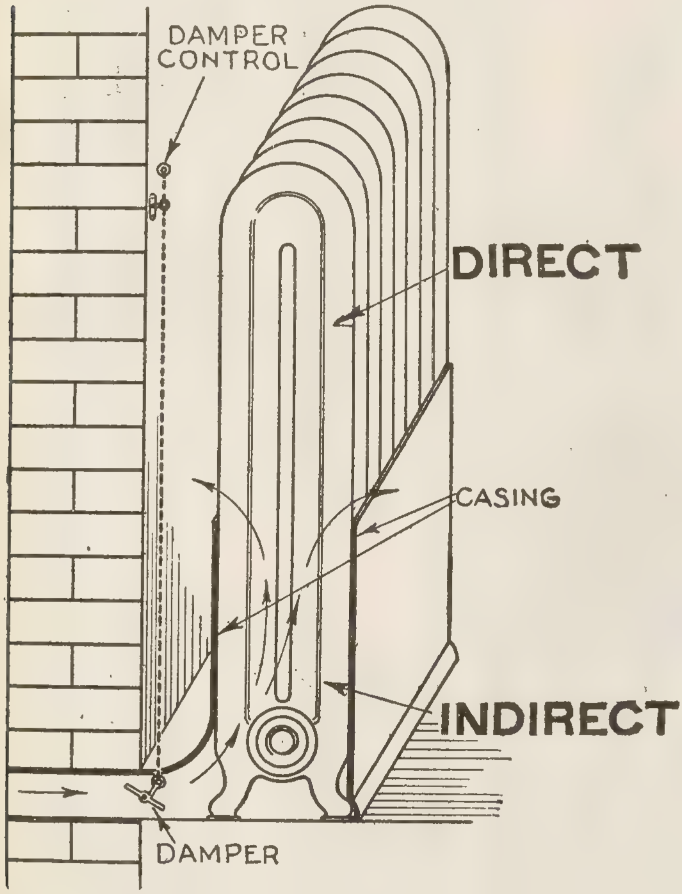


FIG. 8,489.—***Indirect-direct*** heating showing encasement of radiator and air duct connecting radiator with outside. An air damper regulates the amount of air entering.

Indirect heating secures thorough ventilation because, in principle, fresh air from the outside is passed over a radiator placed in an air duct or flue, the heat imparted to the air causing a brisk circulation, thus fresh air is constantly entering the room to be heated, instead of reheating the same air as in direct heating.

In the purely indirect system, the radiating surface (ill advisedly called "heating stack") is placed somewhere remote from the room to be heated, as in fig. 8,488, as distinguished from the *indirect-direct* system in which the radiator is placed within the room to be heated but its lower half is so encased and connected to the outside of the building that fresh air is continually drawn into the room as in fig. 8,489.

Forced Indirect, or Hot Blast Heating.—As generally

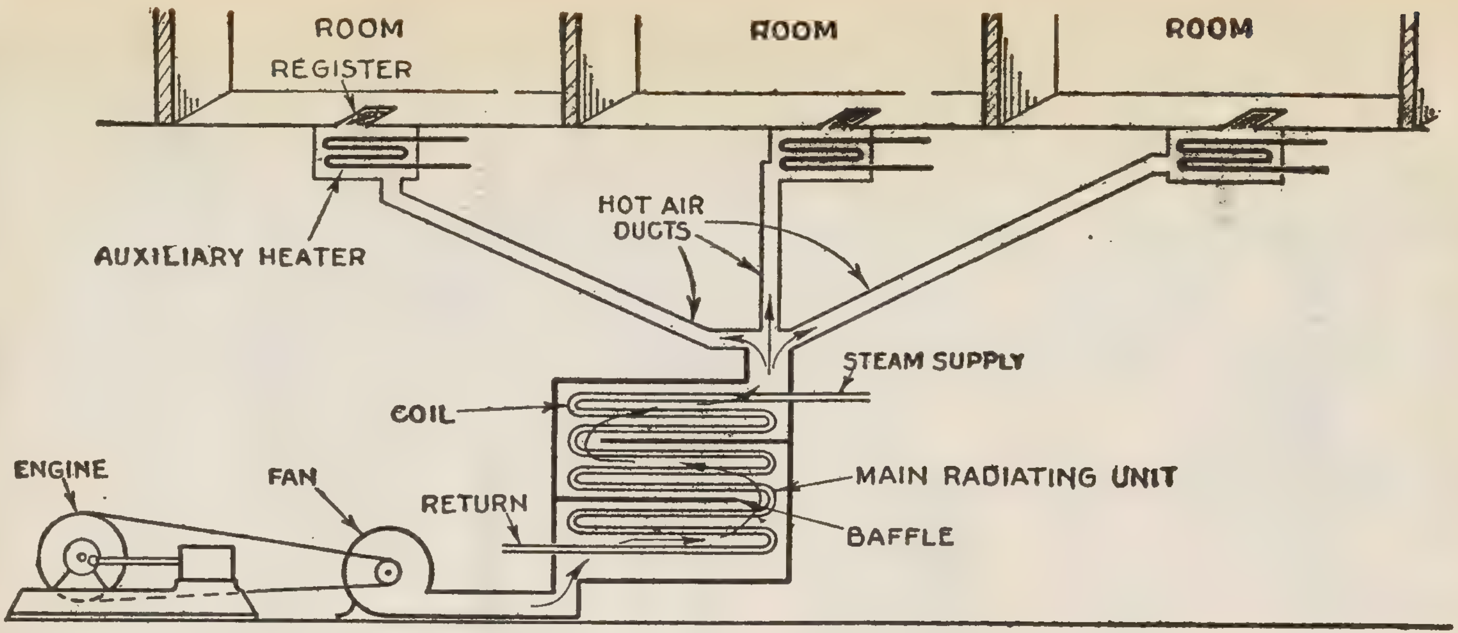


FIG. 8,490.—Hot blast indirect heating with a main radiating unit and individual supplementary heaters.

understood the term hot blast heating refers to indirect heating in which a fan is used to force the air over the radiating surface as distinguished from the natural air circulation just described.

There is usually one large radiating unit from which hot air is supplied to the different rooms through sheet metal ducts with means for regulating the temperature of the air supply to each independently. There are two methods by which this is done.

1. By the use of auxiliary heaters installed in the individual ducts, or,
2. By mixing dampers and two radiating units.

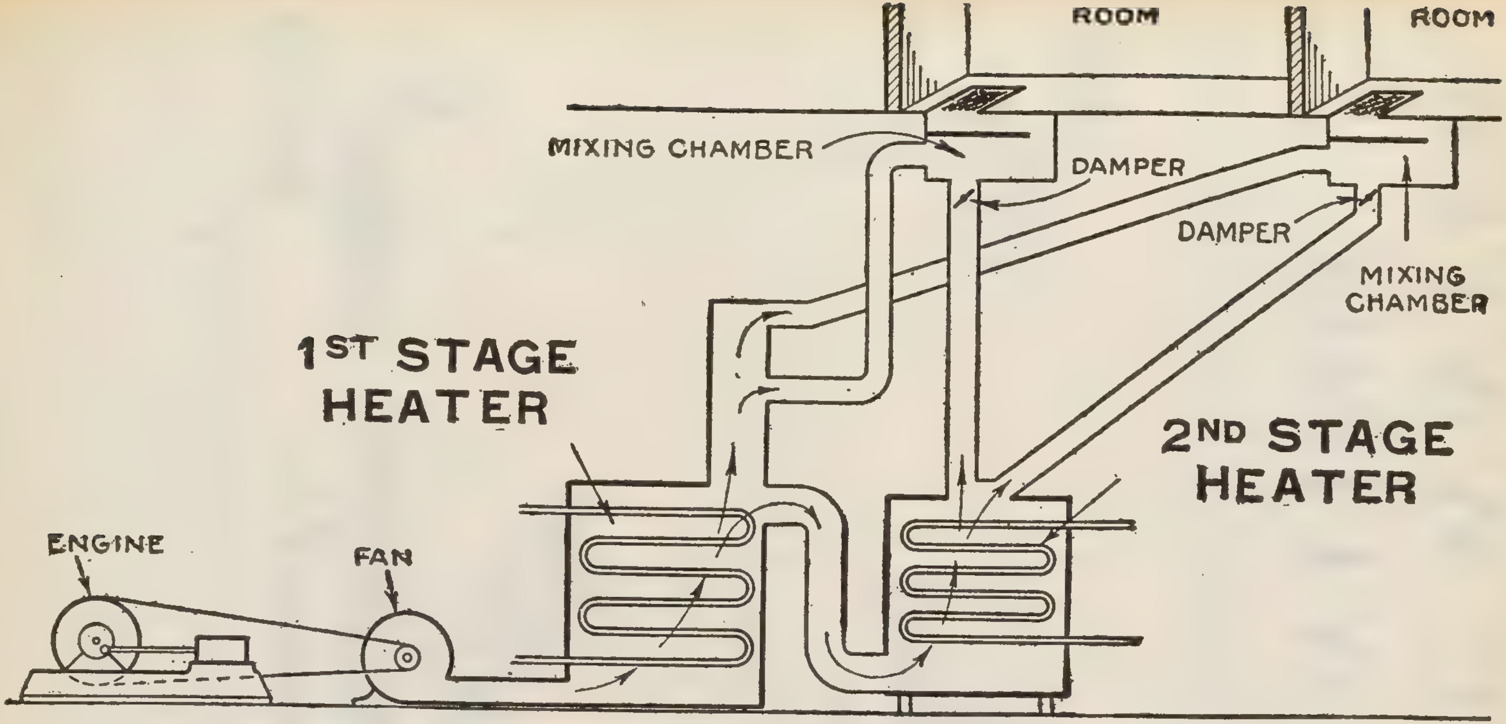


FIG. 8,491.—Hot blast indirect heating with first and second stage main radiating units.

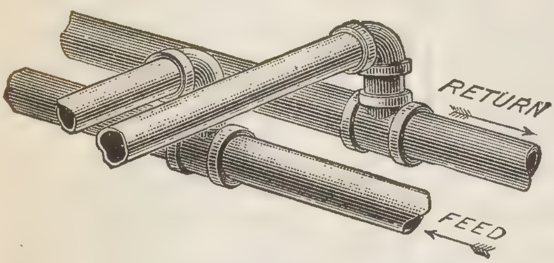
In the first arrangement the air is heated to a temperature of about 70 degrees F. by the main radiating unit and then as much higher as desired by the auxiliary heater, as shown in fig. 8,490.

In the second method, two heaters are provided, one large enough to raise the temperature of the entire air supply to 68 or 70 degrees, and the second arranged to take from ⅓ to ⅖ of the tempered air and raise its temperature as much higher as may be desired. Two ducts are run from the main radiating units to the bases of the uptake ducts, one carrying tempered air, and the other hot air.

A mixing damper is provided at the base of each duct for regulating the temperature of the air to give the required temperature in the rooms, as shown in fig. 8,491.

2 HOT WATER HEATING

Water, as a medium for transmitting heat in heating dwellings possesses several advantages over steam:



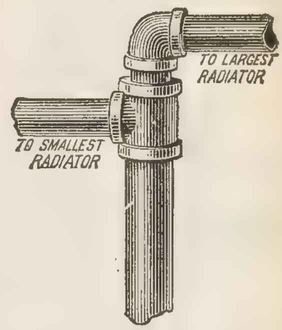
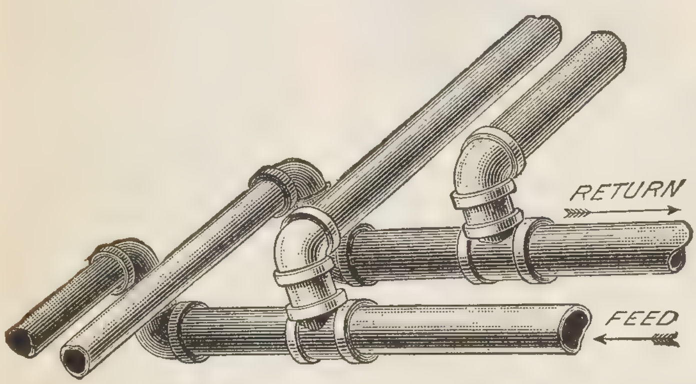


FIG. 8,492.—Best method of taking connection from the top of main flow and return in hot water heating. A 45° elbow may be taken from the top if the head room be limited. Steam connections should be taken off the main in the same way.

FIG. 8,493.—Proper method of taking off connections from a hot water riser on the same floor, one being larger than the other.



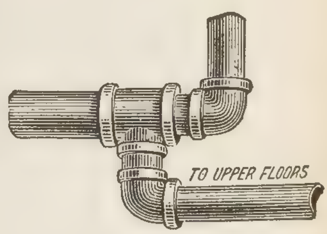


FIG. 8,494.—Best method of taking hot water connections from the end of mains. The end connections should turn up and the pipes run at the same level as the pipes nearer the heater so as to give the last pipes the same advantage as the others.

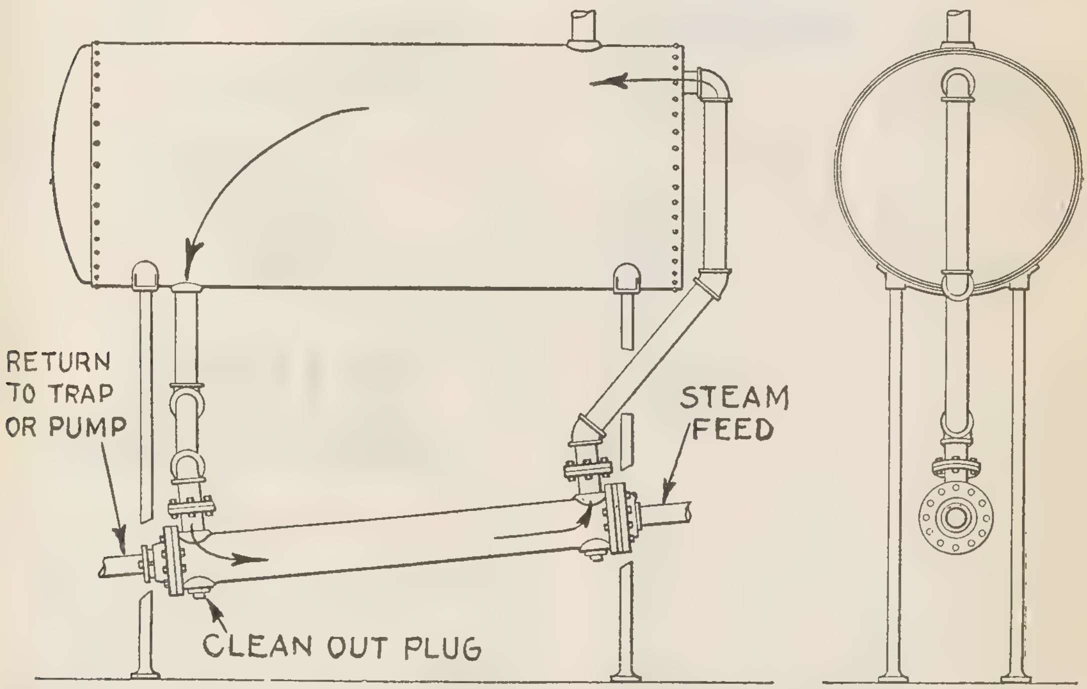
FIG. 8,495.—How connections on hot water risers should be made so as to give all the advantage to the lower floor. The tendency is for the hot water to flow to the upper floors and means similar to the above are necessary to offset this tendency.

NOTE.—The author is indebted to Giblin & Co. for the above illustrated piping suggestions for hot water heating.

1. Because of the low working temperatures the heat is very mild and the atmosphere is not robbed of any of its healthful qualities.

2. Since the temperature may be varied, it is more flexible than low pressure steam systems.

3. The radiators will remain warm a considerable time after the fire is extinguished, thus the system is a reservoir for storing heat.



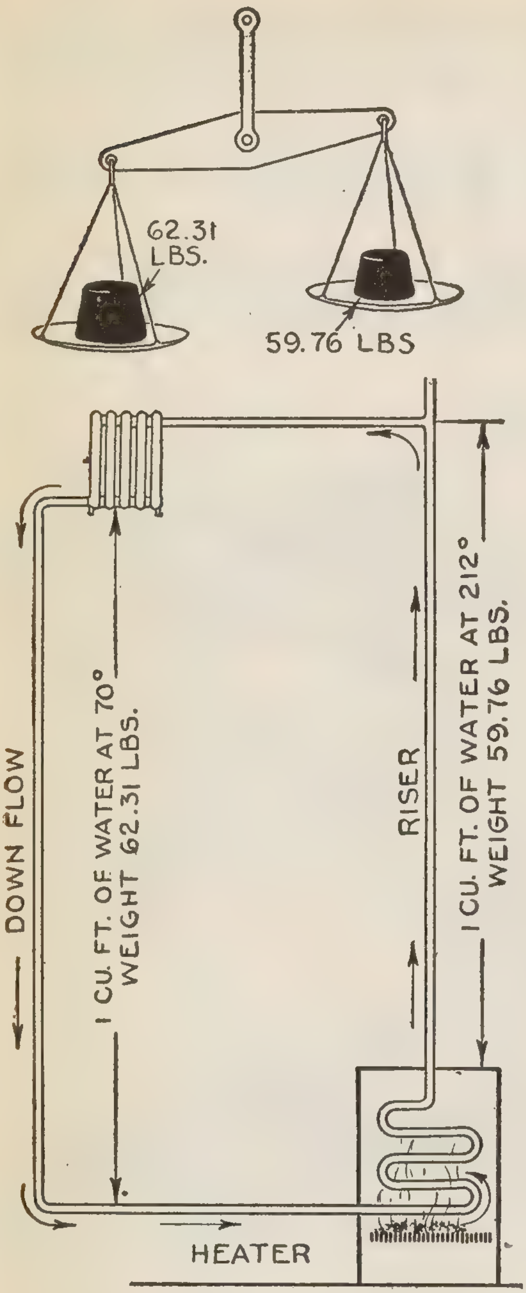
FIGS. 8,496 and 8,497.—Water heater set up in connection with a storage tank. It can be used in this way for exhaust or high pressure steam, and the water of condensation may be returned to a well by a trap, or taken to a pump governor, provided the pump receiver do not carry pressure. The water of condensation should drain freely from the tubes to get good results.

As with steam heat, there are numerous hot water heating systems. These may be classed

1. With respect to circulation, as

a. Natural

b. Accelerated { By excess pressure; " superheating; " steam or air; " pumps



2. With respect to the piping arrangement, as

a. Single pipe system.
b. Two pipe system.
c. Circuit system.
d. Overhead system.

3. With respect to the principle of air circulation, as

a. Direct.
b. Indirect.
c. Indirect direct.

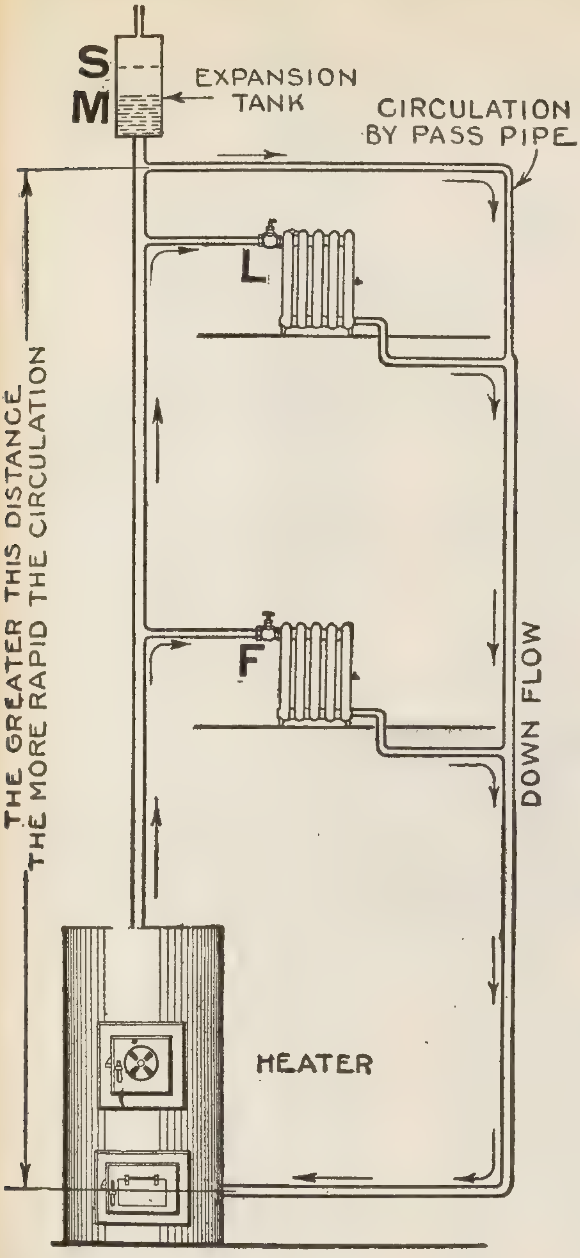
4. With respect to pressure, as

a. Low pressure.
b. High pressure.

NATURAL CIRCULATION

In order that water may transmit heat from the heater to the radiators there must be a constant movement of the water from the heater to the radiators and back again, or *circulation* as it is called. In natural circulation systems, this circulation is

FIGS. 8,498 and 8,499.—Motive force in natural circulation hot water heating system. The question is often asked, "Why does the water circulate?" It is due to the difference in density of water at different temperatures. Thus in fig. 8,499, if the riser pipe hold say 1 cu. ft. of water at 212° its weight is 59.76 lbs., and similarly if the return pipe hold 1 cu. ft. of water at 70°, its weight is 62.31 lbs. Thus the column of water in the return pipe is 62.31—59.76 = 2.55 lbs. heavier than the column of water in the riser. This unbalanced weight forms a motive force which causes the water to circulate through the system as indicated by the arrows, and further portrayed by the effect of the unequal weights placed on the beam scale, fig. 8,498.



due to the difference in density or weight of water at different temperatures.

Thus 1 cubic foot of water at 70 degrees F., weighs 62.31 lbs. and at 212 degrees, 59.76 lbs. representing a difference in weight of 62.31—59.76 = 2.55 lbs., which is available to cause circulation, as shown in figs. 8,498 and 8,499. The difference in weight is due to the *expansion* of water as its temperature is raised.

Fig. 8,500 shows the essential features of a two pipe low

The following table gives the relative volume of water at different temperatures compared with its volume at 39.1° Fahr., according to Kopp, as corrected by Porter.

Expansion of Water

Fahr.	Volume	Fahr.	Volume
39.1	1.00000	122	1.01186
41	1.00001	131	1.01423
50	1.00025	140	1.01678
59	1.00083	149	1.01951
68	1.00171	158	1.02241
77	1.00286	167	1.02548
86	1.00425	176	1.02872
95	1.00586	185	1.03213
104	1.00767	194	1.03570
113	1.00967	212	1.04332

FIG. 8,500.—Two-pipe natural circulation hot water system. ***In operation,*** after the fire is started the temperature of the water in the heater rises, and expands; this disturbs the equilibrium of the system, causing the colder and heavier water in the down flow pipe to flow downward, pushing the warmer and lighter water in the riser upward, thus starting circulation, a circulation by pass pipe being provided to form a continuous path for the flowing water in case all the radiators be shut off. The expansion of the water will cause it to rise in the expansion tank from M to some higher level as S. Now if, valves L and F, be opened the water will flow through the radiators, where most of its heat is absorbed in heating the rooms. This will increase the density of the water in the down flow pipe, thus accelerating the circulation. Air vents on the radiator are necessary. Because of this expansion it is necessary to leave the highest point of a hot water system open to the atmosphere and provide at that point an expansion tank for the variation in volume.

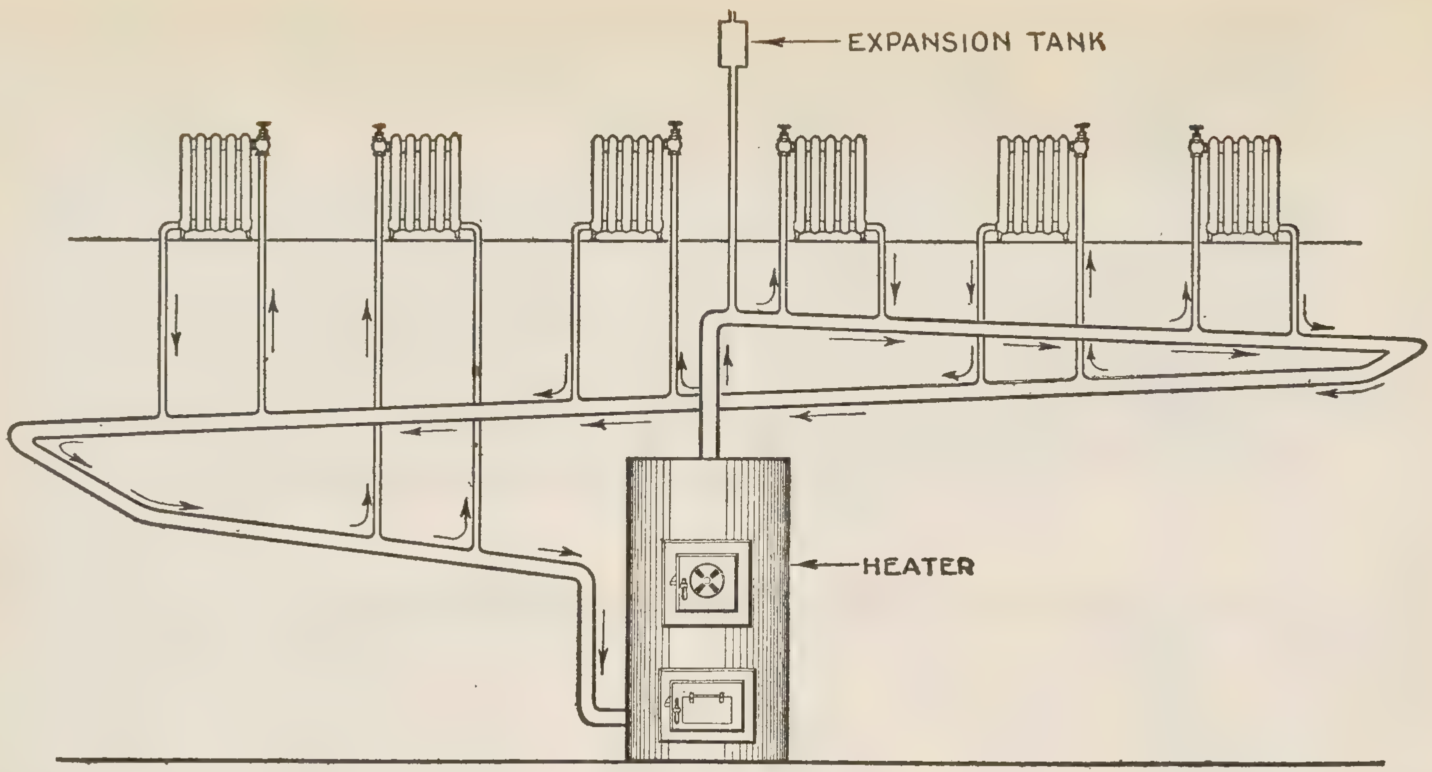
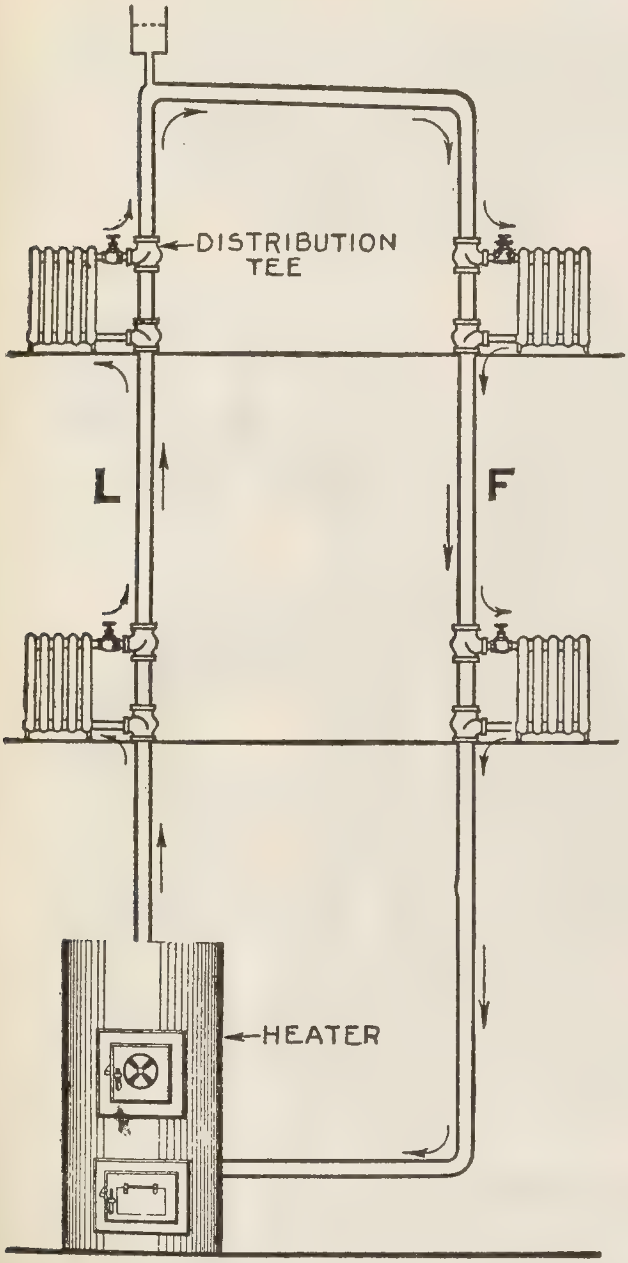


FIG. 8,501.—Circuit two pipe natural circulation hot water system. A single main pipe is taken to a high point under the basement ceiling and then pitched along its run as much as possible to the return inlet of the heater. The risers are taken off the top of the main and the down flow pipes are tapped at the side with tangent tees. Where the riser and return are very close together, a special fitting is used, so arranged that the flow to radiators leaves the top of the main and the return or down flow enter at the bottom. Air vents on the radiators are necessary.

pressure system, this being shown first as it is more easily understood than the so-called one-pipe system.

The circuit system is shown in fig. 8,501. The circuit consists of a closed loop of extra large pipe in the basement, having a pitch not less than ½ inch per 10 feet of run. This main supplies all the risers to the radiators above.

The circulation in this arrangement is not so good as in that of fig. 8,500, and for this reason the circuit main should be of very liberal size to reduce friction to a minimum.



The so called one-pipe system is shown in fig. 8,502. In this arrangement special distribution tees are employed to deflect part of the water from the main into the radiators while letting the balance flow through the main to the next radiator.

This is a single pipe system in the sense that one pipe serves both inlet and outlet of each radiator, but there must be an upflow side L, and a downflow side F, thus there are two main pipes.

Evidently the heat distribution by this method, as well as by the circuit system, fig. 8,501, is not uniform, the radiators on the upflow side L, being hotter than those on the downflow side F.

FIG. 8,502.—So called ***one-pipe*** natural circulation hot water system. L, is the riser side and F, the down flow side. The system consists of a vertical loop which carries both the supply and return water of the radiators. Special distribution tees having an internal baffle tongue facilitate the circulation to and from the radiators, this being shown in detail in fig. 8.503. No air vents on the radiators are necessary.

Fig. 8,504 shows the overhead system. This is virtually the same as the one-pipe system with the addition of a central riser to which no radiators are attached. Special distribution tees are used as in the one-pipe system of fig. 8,502.

High Pressure Hot Water Systems.—The heating systems thus far described are known as low pressure, being open to the atmosphere, although the head on some systems in big buildings

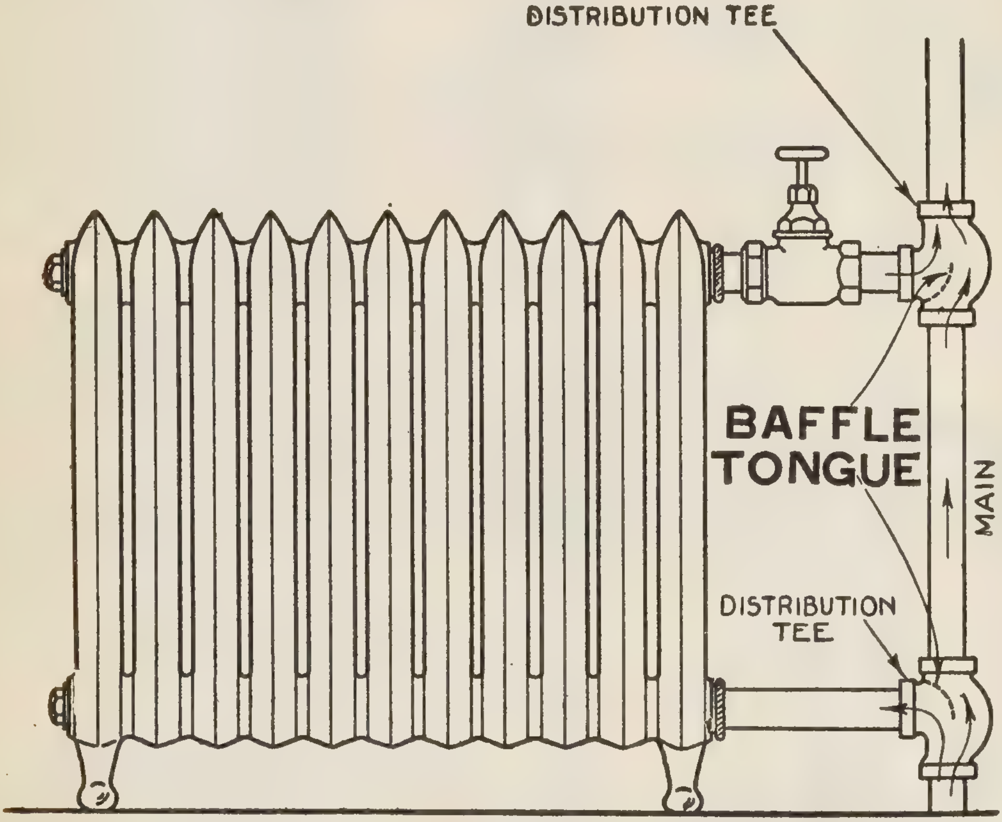


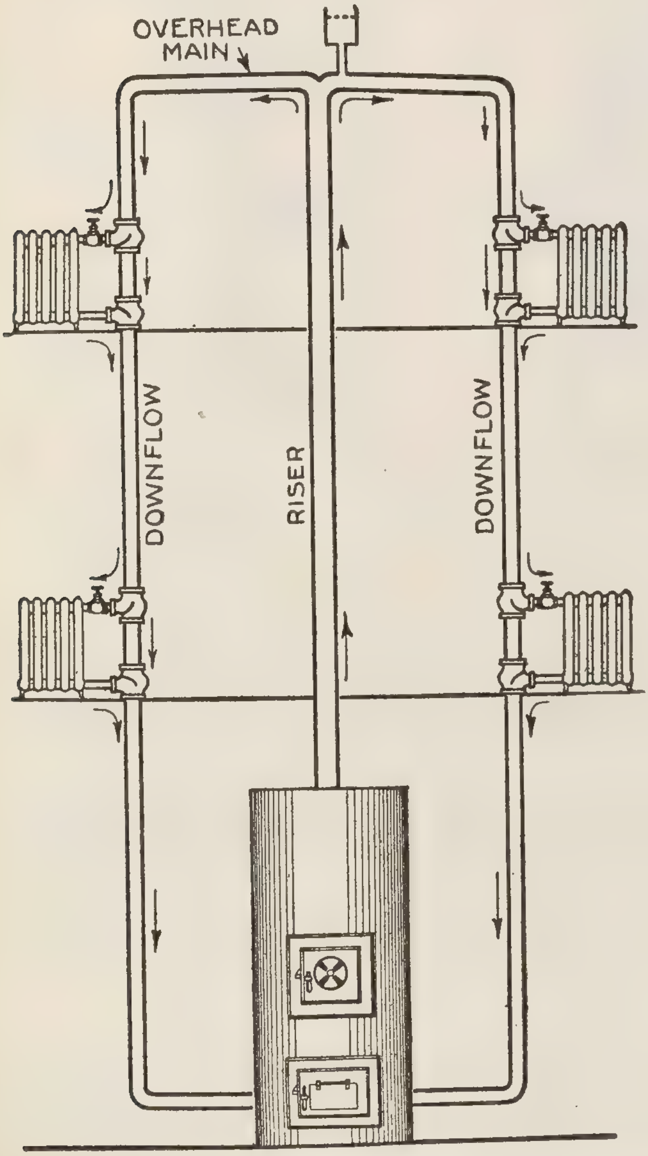
FIG. 8,503.—Distribution tees connecting radiator to main of so called one pipe system, shows baffle tongues which deflect part of the water from the main in and out of the radiator while by passing the balance along the main.

makes them virtually high pressure systems. The object of increasing the pressure is to raise the boiling point, thus the water can be heated to a higher temperature when under high pressure without generating steam, than can be done with low pressure.

In England high pressure hot water systems are used for various purposes,

such as laundry dryers, bake ovens, enameling, etc., the system working at from 250 to 350 degrees. The piping is relatively small, extra heavy pipe and fittings being used.

As distinguished from low pressure plants, high pressure systems are provided with closed expansion tanks, the tank containing water for the system, and air which forms a cushion. The expansion tank is provided with a safety valve.



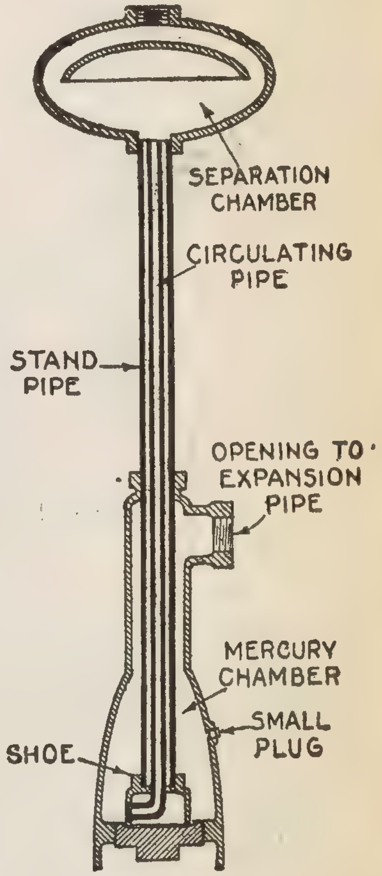


FIG. 8,505.—Honeywell heat generator. ***It consists of*** two pipes, one within the other, the larger pipe termed the stand pipe, the inner one, the circulating pipe. The upper end of the stand pipe is screwed into the bottom opening of a hollow bulb, termed a separating chamber which

FIG. 8,504.—Overhead system. It is considered by some as the best method of piping. Although it is not adapted to all classes of buildings, there are many, such as apartments, stores, office buildings, hotels, etc., where the general arrangement lends itself to this system. No air vents are necessary at any point on the system, as the arrangement is such that all air works to the top and passes off into the expansion tank.

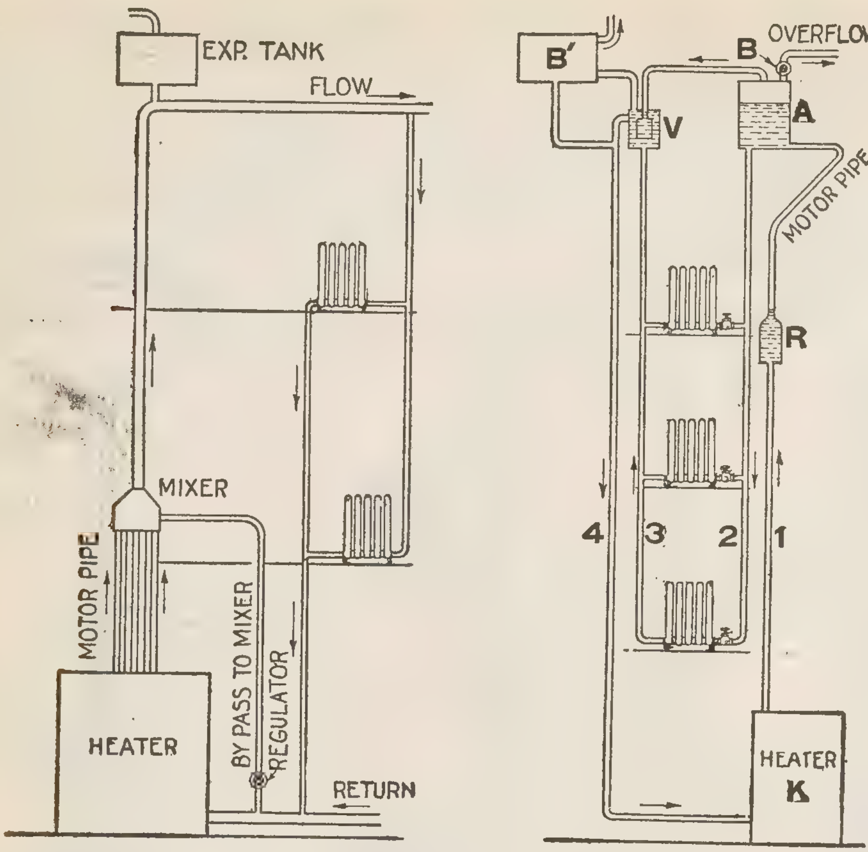


FIG. 8,506.—Koerting hot water heating system. ***It has*** a series of motor pipes leading from the upper part of the heater to a mixer, where the steam is condensed by the water entering through the by pass from the return before it reaches the expansion tank. The velocity of the steam and water through the motor pipes and the partial vacuum caused by the condensation in the mixer produces the acceleration up the flow pipe.

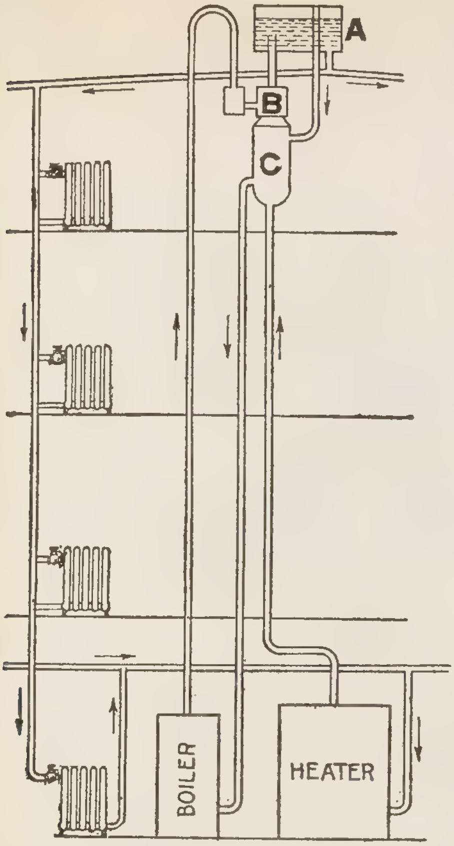
FIG. 8,507.—Jorgensen and Bruchner hot water heating system. The heater K, delivers the hot water up the flow pipe to a regulator R, where a separation takes place between the steam particles and the water, thus causing an acceleration up the motor pipe to the expansion tank A. The water in the flow pipe 2, is probably near to the temperature of that in 1. After passing through the radiators, the water in 3, is at a lower temperature than that in 2. The steam particles which have collected in the expansion tank A, above the water line are condensed in V. The acceleration in the system is thus produced by a combination of the upward movement of the steam particles in motor pipe 1, and the induced upward current in 3, toward the condenser V.

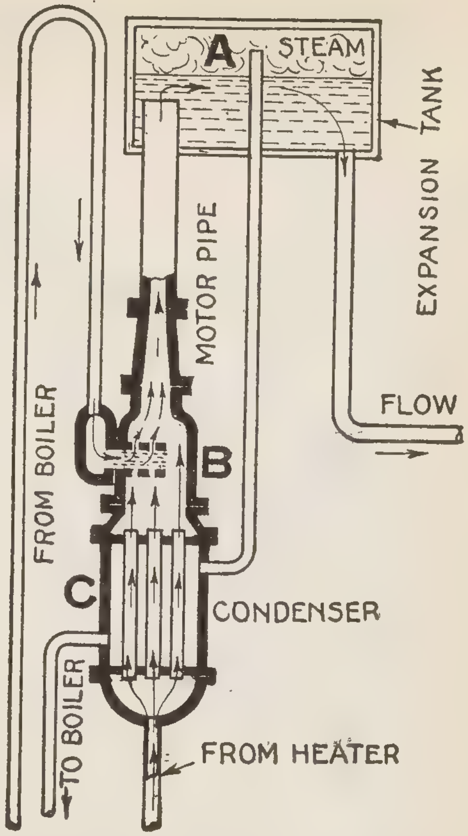
FIG. 8,505.—*Text continued.*

has also an opening at the top into which the pipe connection to the expansion tank is made. The lower half of the stand pipe is screwed into a bottle shaped hollow casting, terminating in a hollow cup of shoe screwed on the bottom of the pipe. The small plug, screwed into the bottom of the bottle makes it tight except for opening on one side near

---

NOTE.—***It will be noticed*** in figs. 8,506 and 8,507 that the condensation in one system takes place before the expansion tank and in other system after it has passed the expansion tank. Each of the systems illustrated may be carried under pressure by a safety valve, or by an expansion tank located high enough to give sufficient static head.





FIGS. 8,508 and 8,509.—Reck system of hot water heating. ***In operation,*** the water passes directly from the heater up the main riser where it enters the condenser C, and thence into the expansion tank A, as a supply to the flow pipes of the system. Steam, from a separate boiler is admitted to the mixer B, above the condenser and enters the circulating water just below the expansion tank. The velocity of the steam and the partial vacuum caused by the condensation induces a current up the flow pipe to the expansion tank. When the water level in the expansion tank reaches the top of the overflow pipe the water returns to the steam boiler through the condenser C, where it gives off heat to the upper current of the circulating water. It will be seen that the water in the system and the steam from the boiler unite from the inlet at the mixer to the expansion tank. On all other parts of the systems they are independent.

FIG. 8,505.—*Text Continued.*

the top of the casting, into which expansion pipe from heating system is connected. The lower part of the bottle is termed the mercury chamber, being filled with mercury to the height of the small plug, making it approximately 1½ in. in depth. The principle of the operation of the generator is based on the fact that mercury is thirteen times heavier than water, and the apparatus is really a mercury seal, requiring a pressure of about ten pounds to break the seal and allow the pressure to reach the expansion tank. The various parts of the generator are so arranged as to allow the mercury to circulate under pressure and to be separated from the water by a plate, when the mercury seal is broken by excess of pressure on the system. As the mercury is heavier than the water, it settles again through inner pipe, into the mercury chamber at the bottom of the generator. The rapidity of the circulation through small piping and reduced radiation, under a temperature equal to steam at ten pounds pressure, renders the reduced amount of radiation (10% reduction), effective for cold weather and the wide range of temperature allows of a mild degree of heat in warmer weather.

ACCELERATED CIRCULATION

By increasing the velocity of the circulation, smaller pipes may be used, thus resulting in a reduction in cost of labor and material. Numerous devices have been introduced to accelerate the circulation and the following principles which have been employed may be mentioned:

1. High pressure to gain greater temperature difference.

2. Superheating a part or all of the circulating water as it passes through the heater and condensing the steam thus formed by mixing it with a portion of the cold circulating water of the down flow pipe.

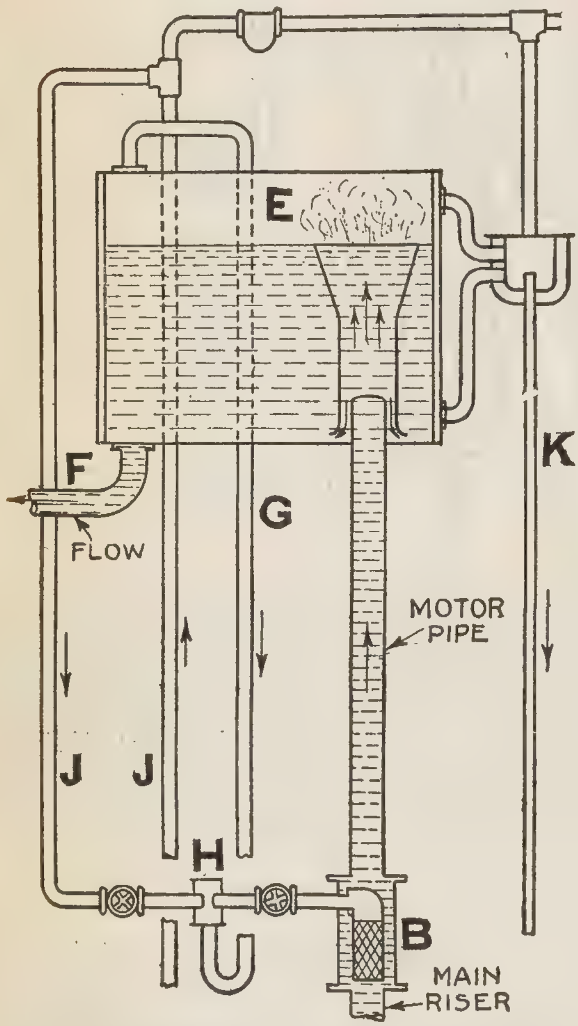


FIG. 8,510.—Modified Reck hot water heating system. ***In this system*** air is injected in the riser pipe at B, and causes the accceleration by a combination of the partial vacuum produced by the steam condensation and the upward current of the air particles as in the familiar air lift. Steam enters through the pipe J, and ejector H, to the mixer at B, where it is condensed. In passing through H, air is drawn from the tank E, and enters the main riser with the steam. The upward movement of this air through the motor pipe to the tank induces an upward flow of the water in the main riser. By this combination there are formed three complete circuits, water, steam and air, uniting as one circuit from the mixer B, to the expansion tank E. The steam furnished may be supplied by a separate steam boiler or by steam coils in the fire box of a hot water boiler.

3. Introducing steam or air into the main riser pipe near the top of the system.

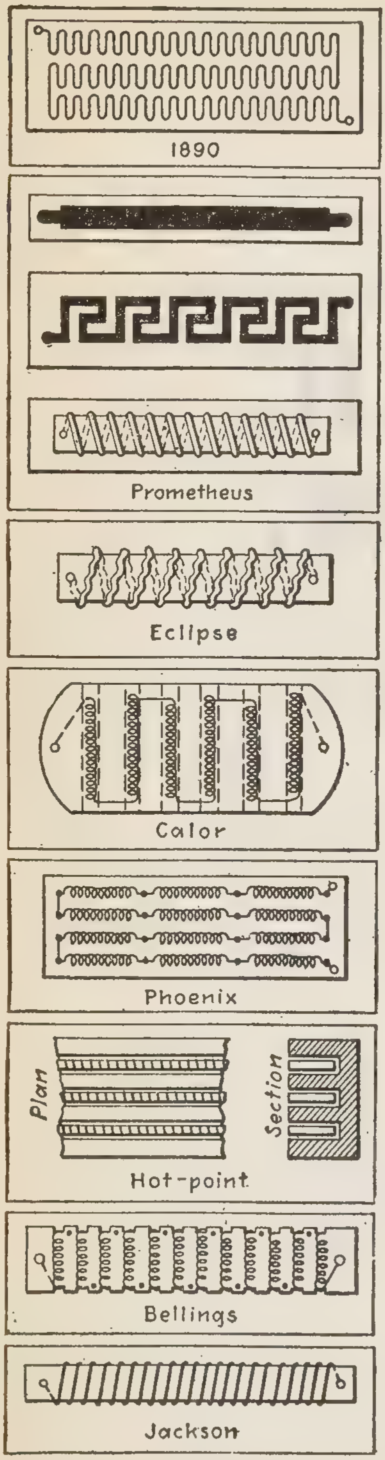
4. Forcing by pumps.

3
ELECTRIC HEATING

Production of the Heat.—For domestic and some industrial purposes, heat is produced by electricity by forcing it through resistance wires, raising the temperature of the latter, and applying the heat thus generated to the articles to be heated. Resistance wires are made of special materials and are capable of withstanding high temperatures without deteriorating. Metals and alloys having high specific resistance or low temperature coefficient of resistance are largely used for resistors.

Heating Units.—The term heating unit is given to that portion of a cooker or heater which gives out the heat for warming an oven or hot plate or for raising the temperature of a room. It consists of some material which is more or less a bad conductor of electricity, and when current is taken through it, by making it form a portion of an electrical circuit, it becomes hot owing to the resistance it sets up to the current. In order to meet the varied conditions of service there are numerous forms of resistor or heating unit, and these may be classified as:

1. Exposed coils of wire or ribbon open to air and wound around insulating material.



FIGS. 8,511 to 8,521.—Various types of heating unit.

2. Wire or ribbon in the form of coils or flat layers, embedded in enamel, asbestos, mica, or other insulators.

3. Filling of metal fixed on enamel, mica, or glass.

4. Metallic powder mixed with clay and compressed in forms, and crystallized silica in tubes of glass.

5. Incandescent filament in vacuum.

Electric radiators for room heating consist usually of a resistance wire wound on asbestos tubes covered with a coating of fire proof cementing compound. When air is thus excluded, German silver may be used as a resistor.

The following details are given of some of the heating units in general use:

The Eclipse element consists of high resistance ribbon crimped to give greater length and free air space, wound over mica strips with the ends connected to heavy eyelet terminals.

The Calor element has a base of fire clay with grooves into which spirals of fine high resistance wire are placed.

The Phoenix element has spiral wire coils held lightly at short intervals by porcelain insulators mounted on a suitable base.

The Hot Point element is made up of nichrome wire or ribbon, wound lightly around thin strips of mica, then further covered with a thin mica covering and inserted very tightly into grooves or slots made in the hot plate or iron base to receive the finished strips.

The Belling element consists of a fire clay strip with spirals of nichrome wire stretched across the width of the base, notches being provided in the base for receiving the ends of the spiral and holding them tightly in position in the manner shown.

The Jackson element has a different class of fire clay base with quite a smooth surface, the section of the strips being a flat oval wire or ribbon of nichrome, is wound tightly over the strip in one continuous length and clamped between heavy terminals at each end.

The Tricity elements consist of nichrome ribbon wound over thin mica and clamped between thin sheets of mica and metal. The method of winding provides for uniform distribution of heat at any loading.

The Bastian or Quartzalite element consists of a spiral of nichrome wire or ribbon coated with a film of oxide insulation. The spiral is held in or on a tube of quartz. The turns of the spiral may be close together without fear of short circuit. This gives it a "hot rod" appearance.

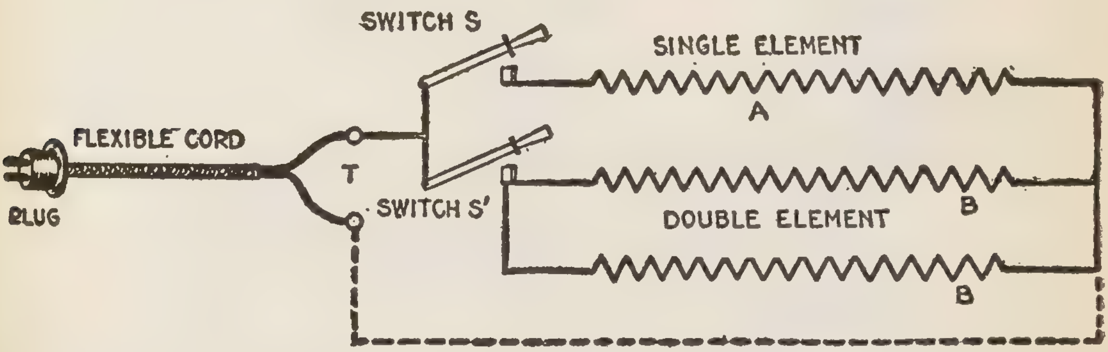


FIG. 8,522.—Arrangement of internal circuit for heaters giving three heating values. ***In the diagram,*** A represents one third of the heating circuit; BB, two thirds. With switch S on, one-third of full heat is given; with S′, two-thirds; while with both S and S′ on, the heater works with full power. At T, are two terminals to which the ends of the flexible cord from the plug are secured.

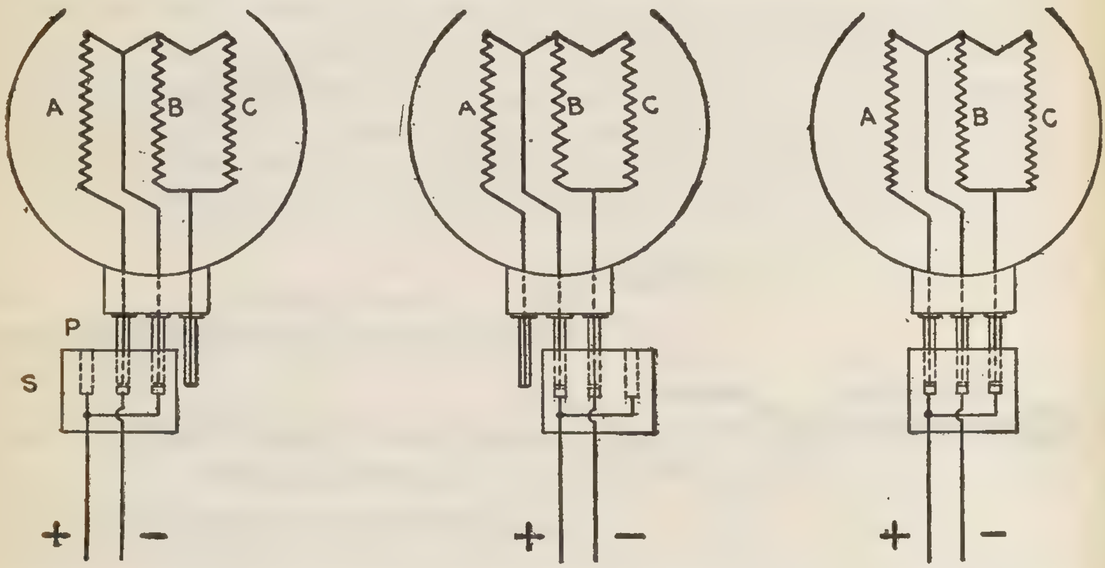
Temperature Regulation in Electric Heaters.—Many appliances have only one internal circuit so that only one heating value can be obtained. There are, however, a great number which have their resistances divided into two or more parts, which can be connected in different ways, so that several heating values can be obtained.

In the simplest case, the internal circuit consists of two parts of equal heating capacity, each being independently controlled

by an ordinary switch, or the two by a double switch, thus permitting operation

1. With either circuit on.
2. With both circuits on.

In some cases the internal circuit is divided into two parts of unequal heating capacity so three heating values can be obtained, by operating



FIGS. 8,523 to 8,525.—Internal circuits of heater. ***As shown,*** the heater wires are divided into three sections: A, B, and C, connected to the external terminals P. A three hole socket S, has one conductor of a twin flexible cord connected to the two outer sockets, and the other to the middle socket. The socket piece may thus be put on the pins in three different ways, as shown in the three figures. In fig. 8,523, section A, only of the heater is in circuit; in fig. 8,524, section B and C are connected, and in fig. 8,525, all sections are in circuit. The signs + and — in each figure indicate the heater end of the flexible cord, the other terminating in a plug connection or switch plug on the wall. In some apparatus, a three or four hole socket is made to fit a corresponding number of pins in one position only, and is connected through a triple or quadruple flexible cord to a two or three way switch adjacent. The various degrees of heat are then obtained by altering the position of the switch.

1. No. 1 circuit alone.
2. No. 2 circuit alone.
3. Both circuits.

Thus, several degrees of control can be obtained by providing enough internal circuit charges.

Room Heating.—Only in a comparatively few instances is electricity employed to advantage in the heating of rooms, such practice being confined chiefly to intermittent auxiliary service in offices and dwellings, ticket booths, or on electric cars where, because of the cheapness of the supply (being generated on a very large scale at the power house), it is desirable for heating. Fig. 8,526 shows the underseat method of car heating and figs. 8,527 to 8,530 the side truss arrangement with wiring diagrams.

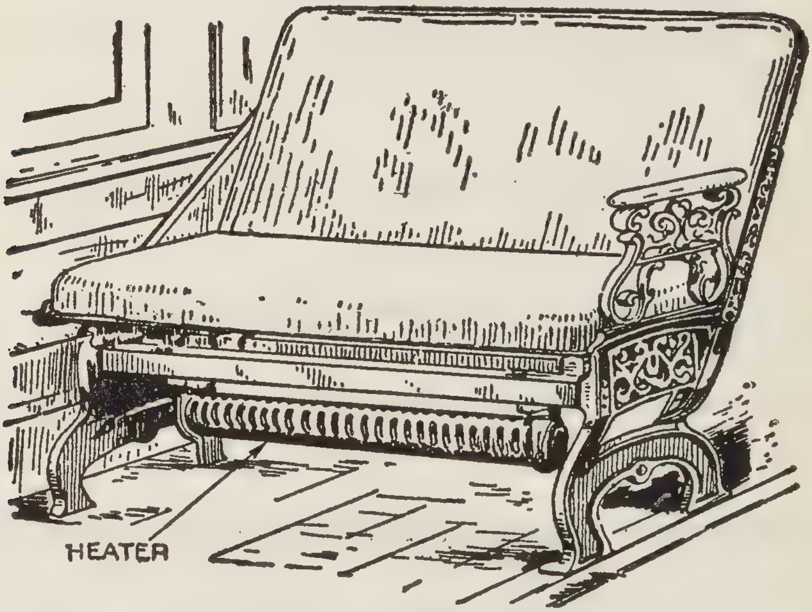


FIG. 8,526.—Underseat method of car heating; view showing seat and placement of heater. At the Montreal meeting of the American Street Railway Association some years ago, Mr. J. F. McElroy read an exhaustive paper on the subject of car heating, from which the following abstracts are taken: ***In practice*** it is found that 20,000 *B.t.u.* are necessary to heat an 18 to 20 foot car in zero weather. When the outside temperature is 12½° F., only 16,000 *B.t.u.* are required, etc., which shows the necessity of having electric heaters adjustable. The amount of heat necessary in a car to maintain a given inside temperature depends on: 1, the amount of artificial heat which is given to it; 2, the number of passengers carried. The average person is capable of giving out an amount of heat in 24 hours which is equal to 191 *B.t.u.* This is evidently an error, as Kent says that a person gives out about 400 heat units per hour, and tests by the Bureau of Standards show approximately the same (413) for a person at rest, and about twice that for a man at hard labor (835).

Loss of Heat from Buildings.—To determine the size of a heating plant it is necessary to first estimate the loss of heat

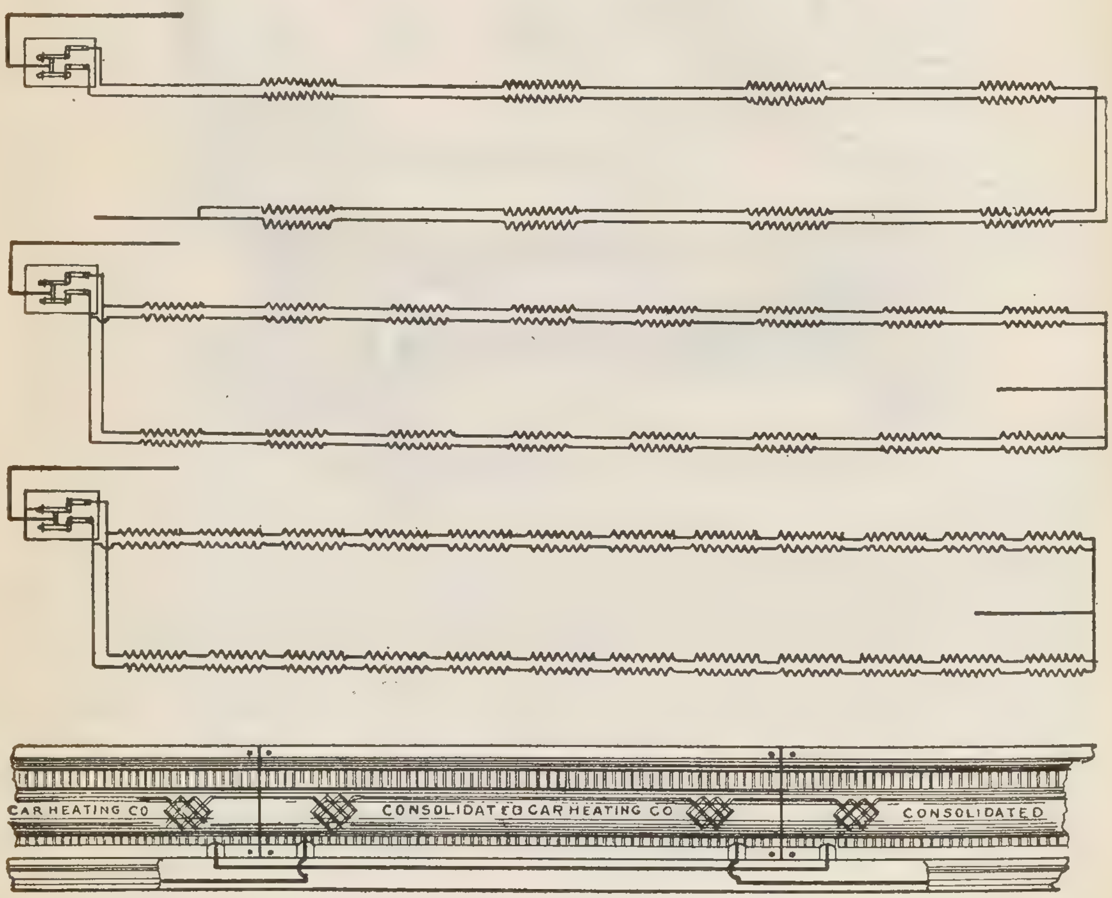
from the building. This is figured on a basis of *B.t.u.* lost per hour. Heat is lost in two ways:

1. By radiation. 2. By convection.

In the first instance, heat is transferred through walls, windows, etc., and lost by radiation, and in the second, it is carried off by the movement of the air as it passes out through the opening in the building.

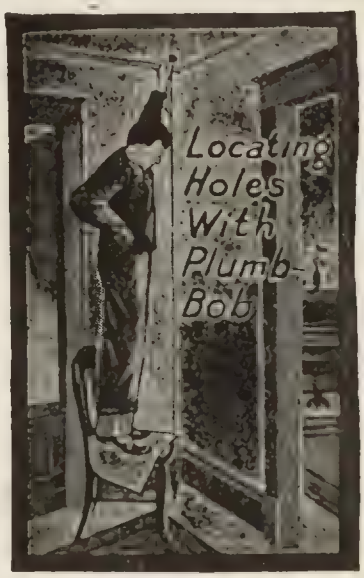
Values for radiation losses by conduction of heat through various materials such as brick, wood, glass, etc., have been given by various authorities as found by experiment. Although these tests agree closely, the results obtained when the materials have been put together in a building sometimes vary quite widely, due to the quality of the workmanship.

The following table, is compiled by the Gurney Heating Co.



FIGS. 8,527 to 8,530.—Wiring diagrams for Consolidated heaters for use along truss plank, and view of truss plank in position showing wiring in moulding. Fig. 8,527, 8 heater equipment; fig. 8,528, 16 heater equipment; fig. 8,529, 24 heater equipment; fig. 8,530. truss plank heater.

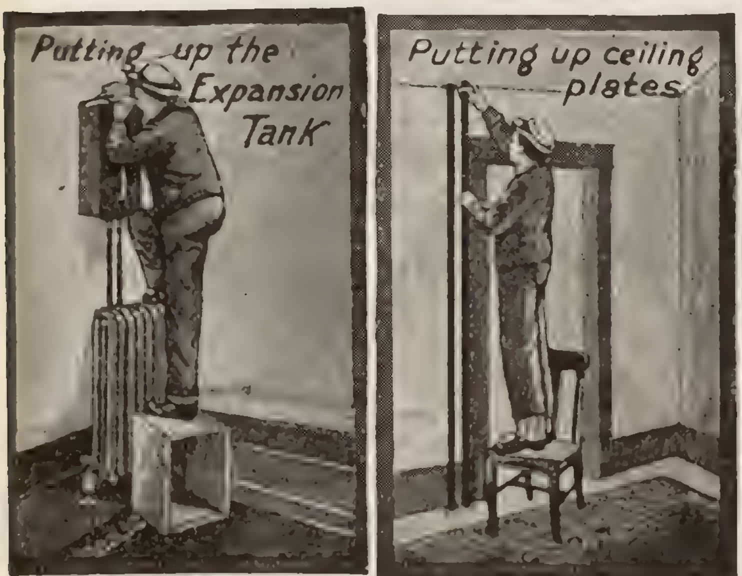
Loss of Heat per Square Foot of Surface			
Material	*B.t.u.* per hour	Material	*B.t.u.* per hour
Masonry		**Partitions, Floors and Ceilings**	
4 inch brick wall..........	.68	Stud partition, lath and plaster one side..........	.26
8 " " "	.46	Stud partition, lath and plaster both sides.......	.15
12 " " "	.32	Ordinary lath and plaster ceiling separating unheated space from heated rooms..........	.26
16 " " "	.26	Floor, single, thickness ¾ inch, warm air above and cold space below:	
20 " " "	.23	A. No plaster beneath joists..........	.20
24 " " "	.3	B. Lath and plaster beneath joists....	.12
28 " " "	.27	Floor, double, thickness 1½ inches, warm room above and cold space below:	
36 " " "	.25	A. No plaster beneath joists..........	.13
44 " " "	.2	B. Lath and plaster beneath joists...	.08
For reinforced concrete add 20 per cent to brick values		**Miscellaneous**	
12 inch stone wall, rubble or block masonry..........	.45	Wood as flooring..........	.83
16 inch stone wall, rubble or block masonry..........	.4	" " ceiling..........	.104
20 inch stone wall, rubble or block masonry..........	.36	" " wall..........	.22
24 inch stone wall, rubble or block masonry..........	.3	Fire proof flooring..........	.124
28 inch stone wall, rubble or block masonry..........	.27	" " ceiling..........	.145
36 inch stone wall, rubble or block masonry..........	.25	Cement as flooring..........	.31
44 inch stone wall, rubble or block masonry..........	.2	Dirt " "	.23
Planks		Wood under slate or composition roof..........	.3
1½ inch pine planks........	.3	Wood, under iron..........	.17
2 " " "	.26	Tile (no boards underneath)	1.25
2½ " " "	.23	Cement roof..........	.6
3 " " "	.2		
Windows, Skylights, and Outside Walls			
Single window..........	1.10		
" " double glass.	.62		
Double "	.50		
Single skylight..........	1.16		
¾ inch sheathing and clapboards..........	.30		
¾ inch sheathing, paper and clapboards..........	.23		



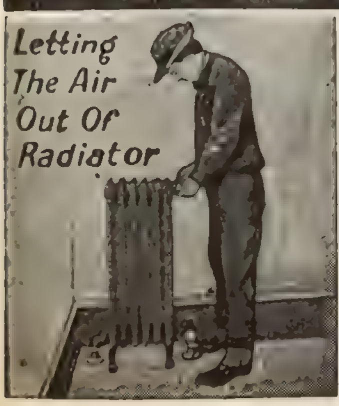
FIGS. 8,531 to 8,535.—Installing an Andrews heating plant.

Example.—What will be the loss of heat in *B.t.u.* per hour in a single room of a brick residence if the temperature inside be maintained at 72 degrees F., when the temperature outside is at 30 degrees, the construction being as follows: 16-inch brick walls; four 3 × 6 windows, northern and western exposure; fire proof flooring and ceiling; size of room 15×20×14 (high). Area of windows 4×(3×5) = 60

Area of walls 2(15+20)×14—60 = 920 square feet
" " floor 15×20 = 300 " "
" " ceiling 15×20 = 300 " "



FIGS. 8,536 to 8,542.—Installing an Andrews heating plant —*Continued.*



The values given for heat losses in the table should be increased as follows:

For northeastern, northwestern, western or northern exposure....................20 to 30%.

For rooms 13 to 14½ feet high...........6½%.

For rooms 14½ to 18 feet high.............10%.

When building is heated during the day only 30%.

When building remains for long periods without heat....................................50%.

B.t.u. lost through windows,	$= 60 \times 1.1$	$\times (72° - 32°)$	$= 2,640$
" " " walls	$= 920 \times .27$	$\times (72° - 32°)$	$= 9,936$
" " " floor	$= 300 \times .124$	$\times (72° - 32°)$	$= 1,488$
" " " ceiling	$= 300 \times .145$	$\times (72° - 32°)$	$= 1,740$
Total loss of heat per hour, normal conditions			15,804 *B.t.u.*

This loss is increased: 30% by northern and western exposure; 6½% for high ceiling, that is, total loss of heat per hour under the special condition is:

$$15,804 \times 1.365 = 21,573 \; B.t.u.$$

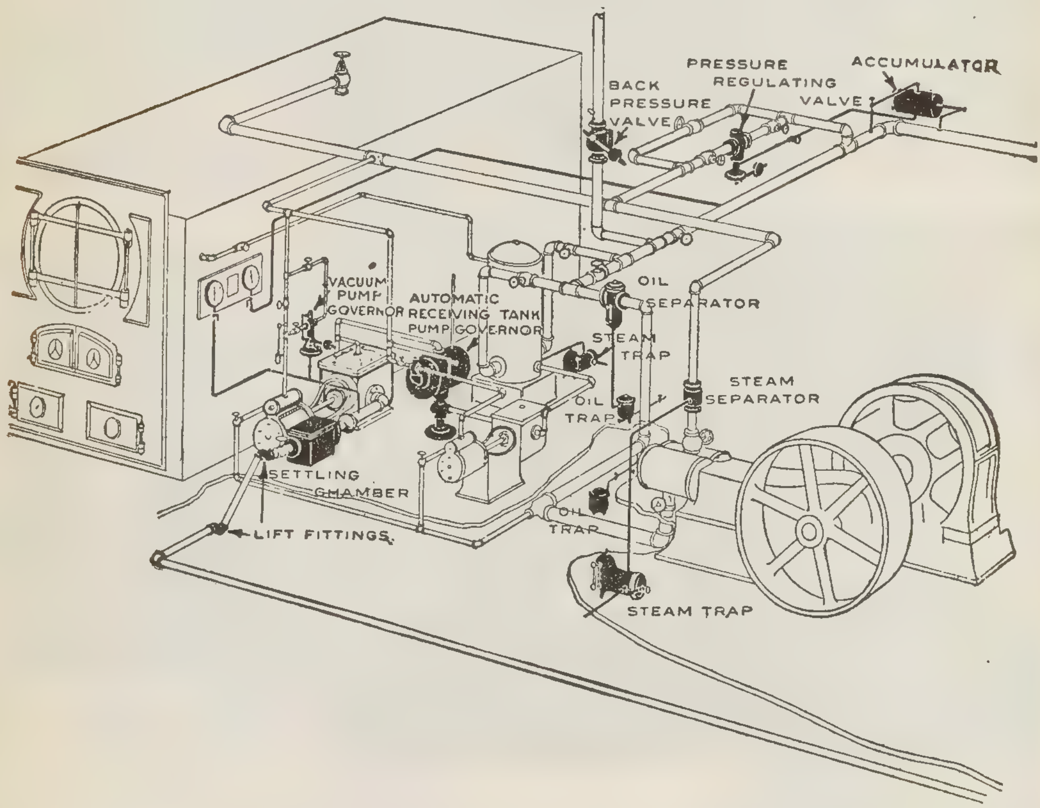


FIG. 8,543.—Van Auken exhaust steam heating system with vacuum distribution showing application to a power plant containing a *closed* feed water heater.

Estimating Radiation.—Repeated tests have shown that the amount of heat given off by ordinary cast iron radiators per square foot of heating surface per hour per degree difference in temperature between the steam or water in the radiator and the air surrounding same to be about 1.6 *B.t.u.* Taking this as a

basis, a steam radiator under 5 lbs. pressure, corresponding to 228°, which is surrounded by air at 70°, Fahr. will give off

$$(228° - 70°) \times 1.6 = 253\ B.t.u.$$

commonly taken as

*250 *B.t.u.**

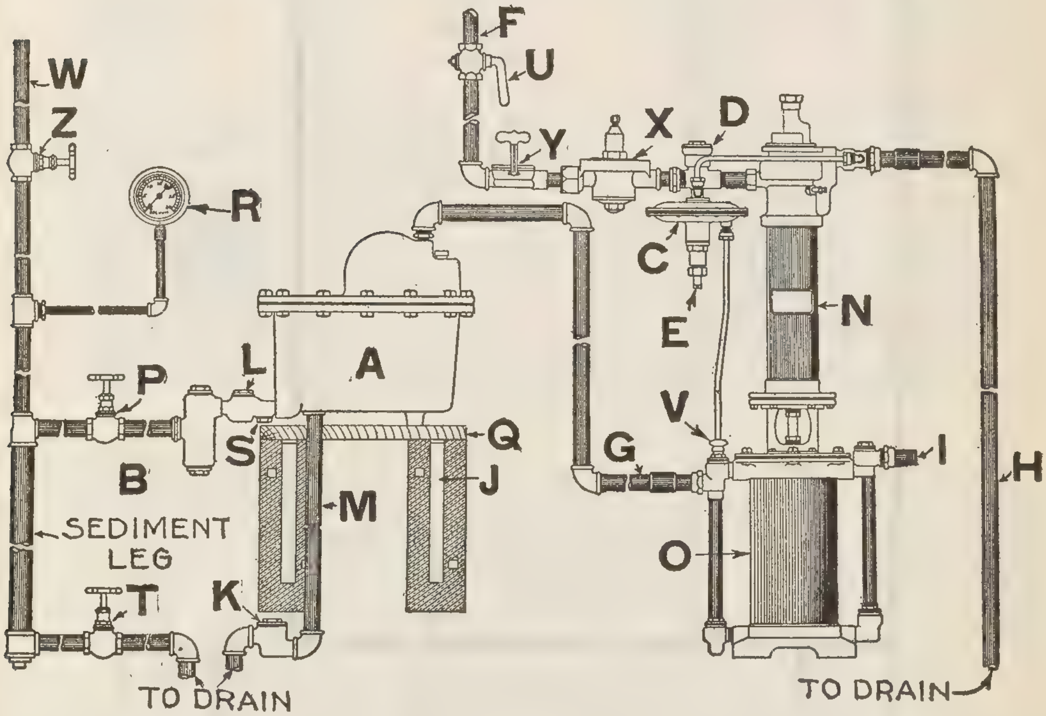


FIG. 8,544.—Bishop-Babcock-Becker hydraulic vacuum pump and equipment. ***The parts are:*** A, separator; B, strainer; C, vacuum controller; D, automatic cut-off; E, vacuum adjusting screw; F, water inlet pipe; G, air suction pipe; H, water outlet pipe; I, air outlet; J, bracket; K, check valve; L, check valve; M, separator drain; N, motive cylinder; O, air cylinder; P, globe valve Q, shelf; R, vacuum gauge; S, separator clean out; T, globe valve; U, water shut-off cock; V. oil cup screw; W, riser to air main; X, water pressure regulator No. 367; Y, water strainer No. 2239; Z, globe valve.

per sq. ft. of heating surface per hour.

With hot water at an average temperature of 160°, the heat given off is

$$(160—70) \times 1.6 = 144 B.t.u.$$

*NOTE.—The author hopes the size of type here used will cause the reader to remember this item.

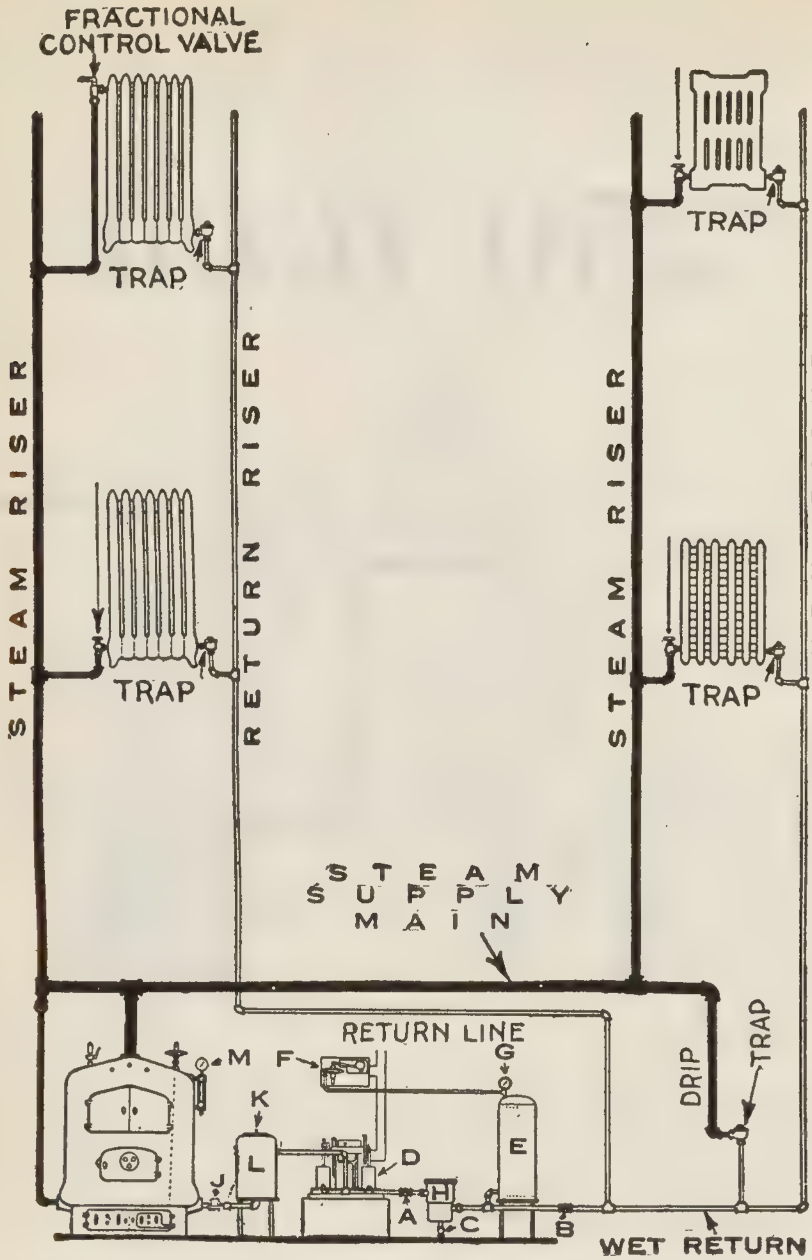


Fig. 8,545.—Bishop-Babcock-Becker return line vacuum heating with electric air pump. Expansion tank E, is connected to wet return line, before it enters strainer. A globe valve B, should be placed on wet return line before it reaches expansion tank connection, so vacuum pump, etc., can be valved off for testing. Vacuum controller F, is connected to expansion tank, and automatic electric switch F, wired to motor and to fuse box. Vacuum guage G, is installed on expansion tank. Strainer H, is connected to wet return line and to vacuum pump. A globe valve A, is placed on line between strainer and pump, so pump can be valved off when necessary. The strainer has a globe valve C, on the drain, and this drain is piped to open sewer. Automatic air separating tank L, is connected to air pump, and to boiler. The back pressure valve J, furnished is installed on line between the separating tank and boiler. The air vent

commonly taken as **150** *B.t.u.* per sq. ft. of heating surface per hour.

In a similar manner the heat given off by radiators working at other temperatures may be determined. The following table gives values for the various systems when the air is at 70° Fahr.

Heat Given Off by Radiators

System	Working pressure	Temperature degrees F.	*B.t.u.* per square foot per hour
Steam (low pressure).......	5 lbs. gauge	228	250
" (atmospheric).......	0 lbs. "	212	227
" (so called vapor).....	5 in. vacuum	203	213
" (vacuum)...........	10 " "	192	195
" "	15 " "	179	174
" "	20 " "	161	146
Water.....................	....	160	150

Fig. 8,545.—*Text continued.*
K, may be piped to chimney or outside, if desired. *All connections should be made perfectly tight.* The system should be thoroughly tested and cleaned, before being put in operation. Before operating, fully open globe valves A, and B, and close valve C. The air pump is started, as soon as fire under boiler is lighted, and immediately draws air from the system. The pump discharges the air into automatic air separating tank, and it passes out of the air vent. The pump will continue to operate until the desired vacuum is created in system, and then it is automatically stopped by means of the automatic electric switch and vacuum controller. This is usually set to stop pump when 7 inches of vacuum has been created, and start it again when vacuum drops to 5 inches. When steam reaches the traps these thermal members expand thus preventing steam passing into the return line temperature. It is quickly pulled into the radiators, so rapid heating is assured throughout entire system. The instant steam reaches the traps their thermal members expand closing traps, so steam cannot pass into return line. When steam condenses in radiators, condensation at 190 to 198 degrees cools the thermal members, causing them to contract. This opens traps, and *all* condensation and air passes out quickly, after which steam following again expands thermal members closing the traps until more condensation accumulates. The condensation and air after passing out of radiators is drawn out of return piping (assisted by vacuum in expansion tank) through strainer, into vacuum pump. The pump forces condensation and air into automatic air separating tank, and when this tank is full of condensation, and contains a greater pressure than boiler, the back pressure valve opens automatically, allowing condensation to pass into boiler. The air escapes through air vent in separating tank, in manner already described. As condensation never remains in system, there can be no hammering or banging noises, and no danger of freezing. *The parts are:* A, globe valve; B, globe valve; C, globe valve; D, electric air pump; E, expansion tank; F, automatic electric switch and vacuum controller; G, vacuum gauge; H, strainer; J, back pressure valve; K, air vent; L, automatic air separating tank; M, compound gauge.

The values **250** *and* **150** *for low pressure steam and hot water respectively although only approximate, are standard values for ordinary calculations.*

Example.—How many sq. ft. of radiator surface are required to heat the room in the previous example for low pressure steam and hot water radiators

Total heat loss per hour is 22.293*B.t.u.*

For steam	sq.ft. radiator surface	=22.293÷250= 89
" hot water	" " " "	=22.293÷150=149

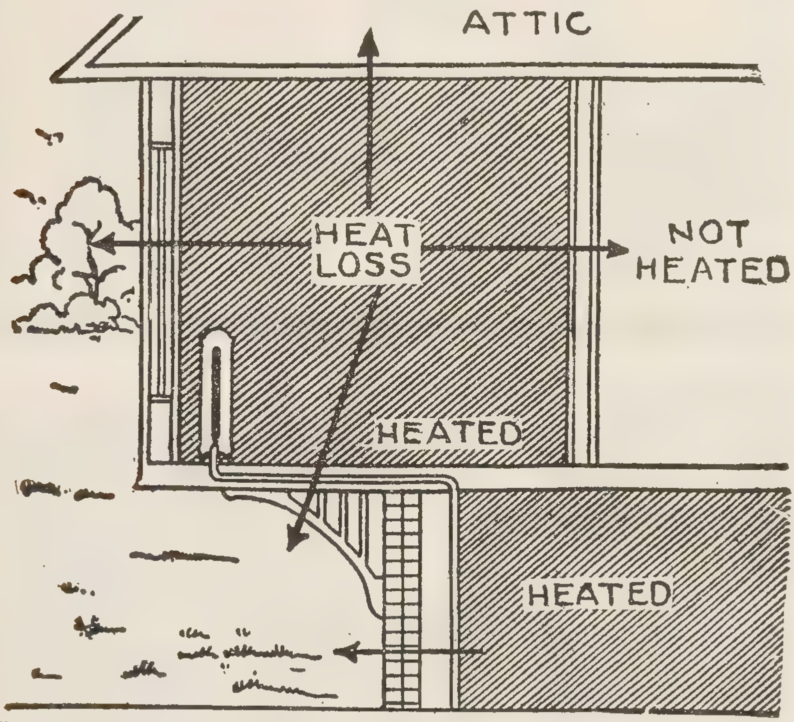


Fig. 8,546.—Heat losses due to exposed floor, ceilings and walls.

Miscellaneous Rules.—There are any number of so called "rules" for quick and approximate calculation and they should be considered only as such in using them. The following are for figuring direct radiation based on wall and glass exposures:

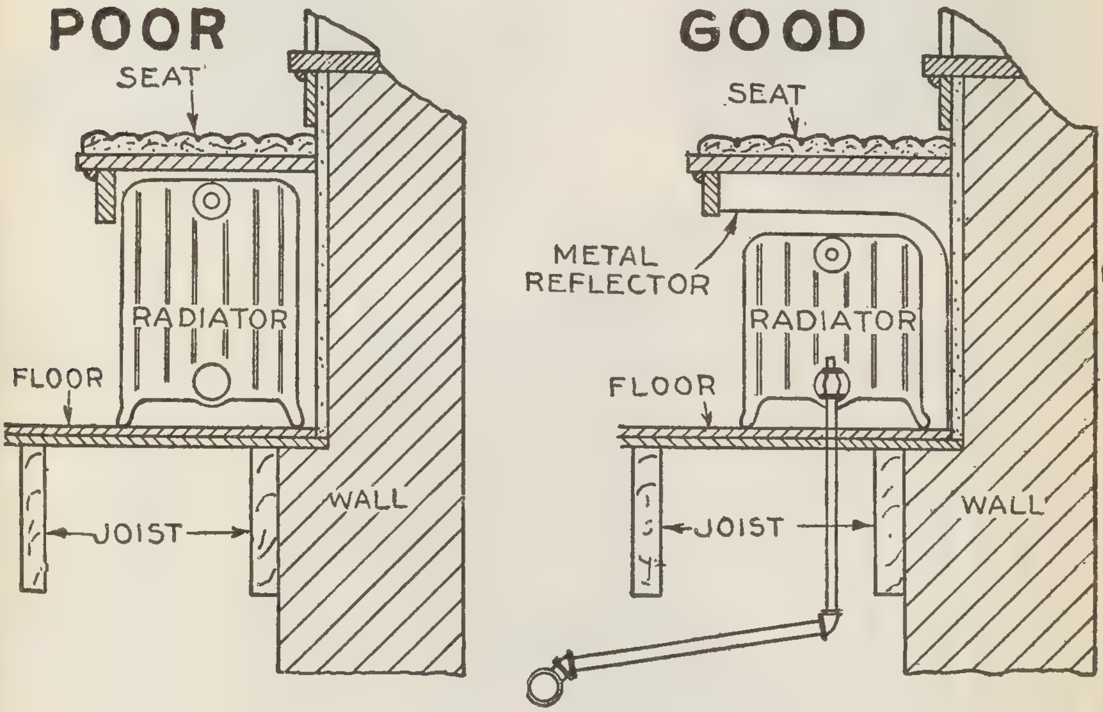
John H. Mills: One square foot of radiating surface for each two square feet of glass, and for each twenty square feet of outside wall, and every two hundred cubic feet of space.

Example:

Glass exposure, square feet,	60; (1 to 2)	=30
Wall outside, square feet,	210; (1 to 20)	$=10\frac{1}{2}$
Cubical contents, cubic feet,	2,016; (1 to 200)	=10
Total		$50\frac{1}{2}$ sq. ft. steam.

For water, by generally accepted standards, add 60 per cent equals 81 sq. ft.

Professor R. C. Carpenter, Cornell University: To the square feet of glass surface, add one quarter of the exposed wall surface, and $^1/_{55}$ to $^3/_{55}$ of cubical contents. ($^1/_{55}$ for rooms on upper floors, $^2/_{55}$ for rooms on first

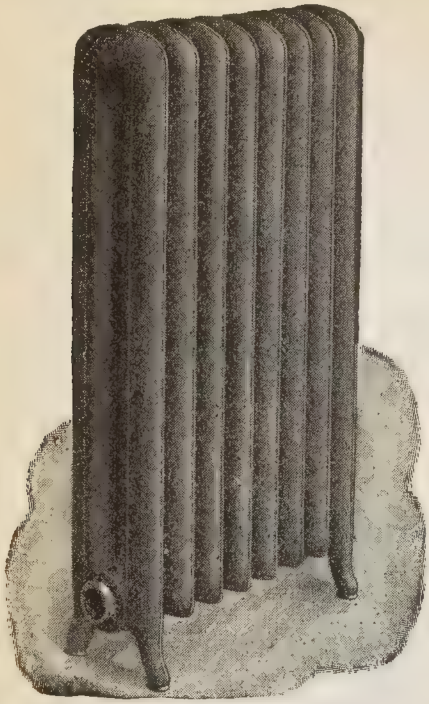


FIGS. 8,547 and 8,548.—Wrong and right way to install radiator under seat.

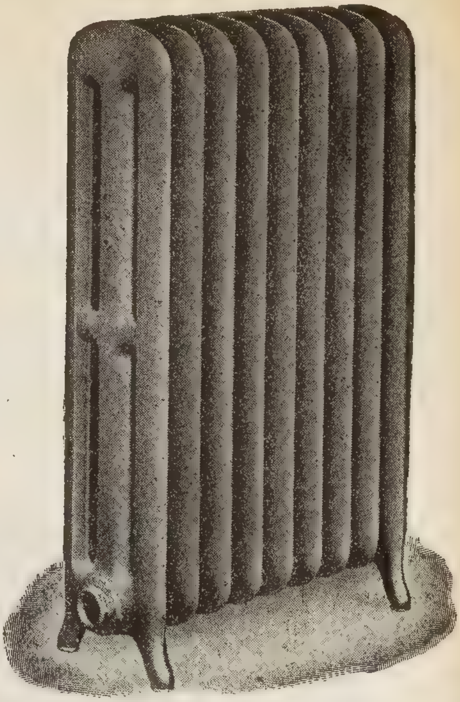
floor, and $^3/_{55}$ for large halls); then for steam multiply by .25, and for water by .40.

Example.—Room as above.

Glass exposure, 60 square feet, to which add one-quarter of wall $210 \div 4 = 53$, to which add (room first floor) $^2/_{55}$ cubical contents $^2/_{55} \times 2{,}016 = 73$. Thus $60 \times 53 \times 73 = 186 \times .25$ (for steam) $= 47$ square feet; or, $186 \times .40$ (for water) $= 74$ square feet.



Figs. 8,549 and 8,550.—American Radiator two and three column "Peerless" radiators.



Peerless Two-Column Radiators
For Steam and Water

No. of Sections	* Length 2½ in. per Sec.	Heating Surface—Square Feet: 45-in. Height 5 Sq.Ft. per Sec.	38-in. Height 4 Sq.Ft. per Sec.	32-in. Height 3⅓ Sq.Ft. per Sec.	26-in. Height 2⅔ Sq.Ft. per Sec.	23-in. Height 2⅓ Sq.Ft. per Sec.	20-in. Height 2 Sq.Ft per Sec
2	5	10	8	6⅔	5⅓	4⅔	4
3	7½	15	12	10	8	7	6
4	10	20	16	13⅓	10⅔	9⅓	8
5	12½	25	20	16⅔	13⅓	11⅔	10
6	15	30	24	20	16	14	12
7	17½	35	28	23⅓	18⅔	16⅓	14
8	20	40	32	26⅔	21⅓	18⅔	16
9	22½	45	36	30	24	21	18
10	25	50	40	33⅓	26⅔	23⅓	20
11	27½	55	44	36⅔	29⅓	25⅔	22
12	30	60	48	40	32	28	24
13	32½	65	52	43⅓	34⅔	30⅓	26
14	35	70	56	46⅔	37⅓	32⅔	28
15	37½	75	60	50	40	35	30
16	40	80	64	53⅓	42⅔	37⅓	32
17	42½	85	68	56⅔	45⅓	39⅔	34
18	45	90	72	60	48	42	36
19	47½	95	76	63⅓	50⅔	44⅓	38
20	50	100	80	66⅔	53⅓	46⅔	40
21	52½	105	84	70	56	49	42
22	55	110	88	73⅓	58⅔	51⅓	44
23	57½	115	92	76⅔	61⅓	53⅔	46
24	60	120	96	80	64	56	48
25	62½	125	100	83⅓	66⅔	58⅓	50
26	65	130	104	86⅔	69⅓	60⅔	52
27	67½	135	108	90	72	63	54
28	70	140	112	93⅓	74⅔	65⅓	56
29	72½	145	116	96⅔	77⅓	67⅔	58
30	75	150	120	100	80	70	60
31	77½	155	124	103⅓	82⅔	72⅓	62
32	80	160	128	106⅔	85⅓	74⅔	64

Peerless Three-Column Radiators
For Steam and Water

No. of Sections	* Length 2½ in. per Sec.	Heating Surface — Square Feet: 45-in. Height 6 sq. ft. per Sec.	38-in. Height 5 sq. ft. per Sec.	32-in. Height 4½ sq. ft. per Sec.	26-in. Height 3¾ sq. ft. per Sec.	22-in. Height 3 sq. ft. per Sec.	18-in. Height 2¼ sq. ft. per Sec.
2	5	12	10	9	7½	6	4½
3	7½	18	15	13½	11¼	9	6¾
4	10	24	20	18	15	12	9
5	12½	30	25	22½	18¾	15	11¼
6	15	36	30	27	22½	18	13½
7	17½	42	35	31½	26¼	21	15¾
8	20	48	40	36	30	24	18
9	22½	54	45	40½	33¾	27	20¼
10	25	60	50	45	37½	30	22½
11	27½	66	55	49½	41¼	33	24¾
12	30	72	60	54	45	36	27
13	32½	78	65	58½	48¾	39	29¼
14	35	84	70	63	52½	42	31½
15	37½	90	75	67½	56¼	45	33¾
16	40	96	80	72	60	48	36
17	42½	102	85	76½	63¾	51	38¼
18	45	108	90	81	67½	54	40½
19	47½	114	95	85½	71¼	57	42¾
20	50	120	100	90	75	60	45
21	52½	126	105	94½	78¾	63	47¼
22	55	132	110	99	82½	66	49½
23	57½	138	115	103½	86¼	69	51¾
24	60	144	120	108	90	72	54
25	62½	150	125	112½	93¾	75	56¼
26	65	156	130	117	97½	78	58½
27	67½	162	135	121½	101¼	81	60¾
28	70	168	140	126	105	84	63
29	72½	174	145	130½	108¾	87	65¼
30	75	180	150	135	112½	90	67½
31	77½	186	155	139½	116¼	93	69¾
32	80	192	160	144	120	96	72

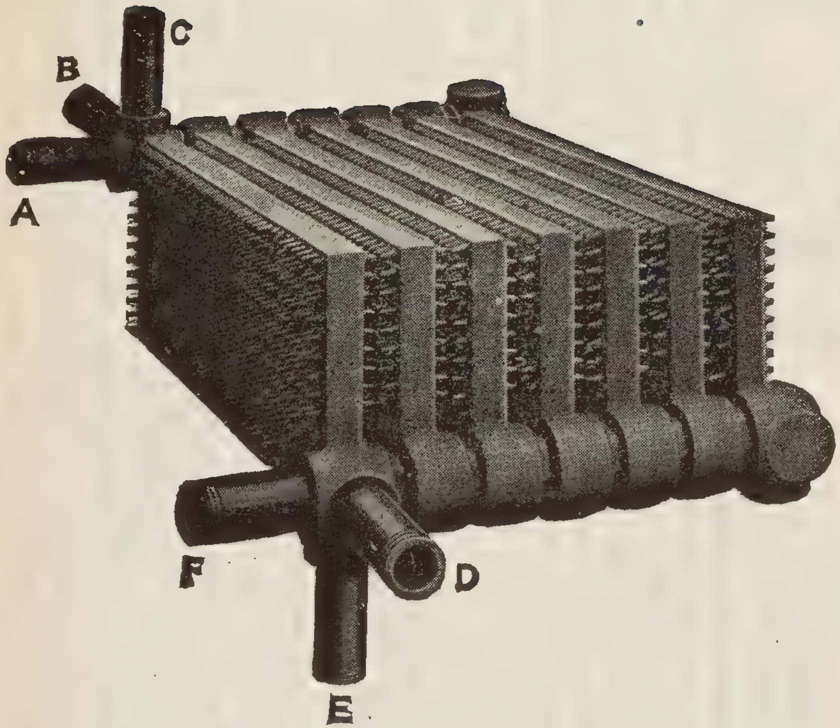


FIG. 8,551.—United States pin indirect radiator for steam or hot water. Heating surface 10 sq. ft. per section. Tappings can be made at A, B, C, D, E, or F, but are regularly made at F. These tappings are: pin, 10 ft. section as above, 1½ in.; pin 15 and 20 ft. sections 2 ins.

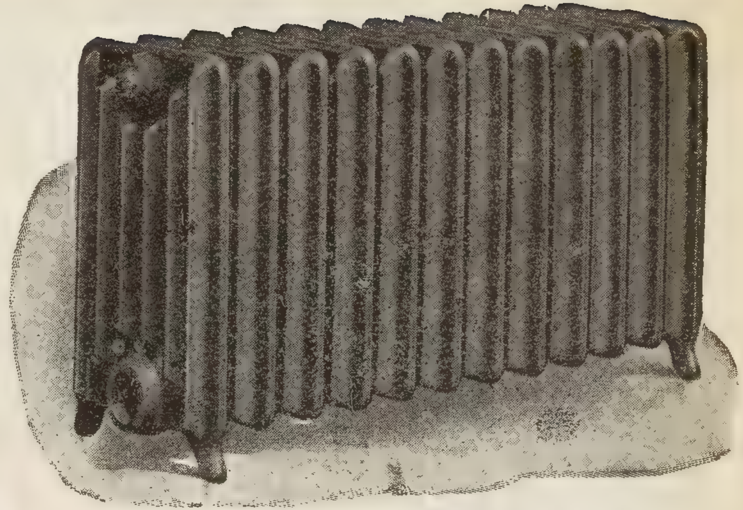


FIG. 8,552.—American Radiator Co. "Peerless" radiator.

Peerless Window Radiators

No. of Sections	Length Inches per Section	Heating Surface — Square Feet		
		20-in. Height 5 sq. ft. per Section	16-in. Height 3¾ sq. ft. per Section	13-in Height 3 sq. ft. per Section
2	6	10	7½	6
3	9	15	11¼	9
4	12	20	15	12
5	15	25	18¾	15
6	18	30	22½	18
7	21	35	26¼	21
8	24	40	30	24
9	27	45	33¾	27
10	30	50	37½	30

Mott Iron Works.—While the radiating surface which will be required in any room largely depends upon the proportion of exposed wall and glass surface, there must, however, be some relation to the cubical contents of same. Hence, as the simplest and most readily comprehended rule of apportioning radiation the following table is given as representing the experience of the best heating engineers:

Radiation Tables

(For steam and hot water)

Dwellings	Cu. ft. of space using steam	Cu. ft. of space using hot water
Living rooms, one side exposed..........	50 to 55	25 to 30
" " two sides "	45 " 50	20 " 25
" " three " "	40 " 45	15 " 20
Sleeping "	50 " 70	30 " 35
Halls and bath rooms.....................	40 " 50	20 " 30
Public Buildings		
Offices..................................	50 " 25	30 " 40
Schools..................................	40 " 60	20 " 30
Factories and stores.....................	70 " 100	40 " 60
Assembly halls and churches..............	100 " 150	60 " 80

For direct indirect *steam* radiation, add 25%, and for indirect, 60%, to the amount of direct surface to secure equal value of heating surface.

For direct indirect *water* radiation, add 33⅓%, and for indirect, 75%, to the amount of direct surface to secure equal value of heating surface.

Allowances should be made for extraordinary conditions such as buildings of unusual character, location, exposure, and quality of construction, loose windows and doors and unusual glass exposure, and the necessary lengths of distributing mains.

In apportioning the amount of indirect surface to be used in connection with a heating system, it should be remembered that this manner of heating should be in connection with some system of ventilation, and therefore

NOTE.—***Tapping radiators.*** Steam or vapor is lighter than air or water, and, therefore, by introducing the lighter element, steam, at the top of a radiator and removing the heavier elements, air and water, from the bottom, the laws of nature are followed, and accelerated circulation results. Radiator valves are easier to get at, when at the top of a radiator, also. Tapping the supply and return at one end facilitates the removal of a radiator or increasing its size, if building changes make it necessary, by adding sections to the opposite end without disturbing pipe connections. Bear in mind that the efficiency of the radiating surface determines the tapping, and not the size or surface alone. Pipe coils require special consideration to secure adequate steam supply. The supply connections must also be arranged to give each pipe its proper supply of steam. Failure to observe certain requirements has given pipe coils a bad reputation as radiators.

a larger volume of air must be warmed than when using direct radiation, and proportionately with the system of ventilation. In buildings with a medium provision for ventilation, it is a good practice to add 75 per cent to that which would be required in direct surface to obtain the amount of indirect required.

Indirect Heating.—The amount of heat given off by an indirect radiator depends upon:

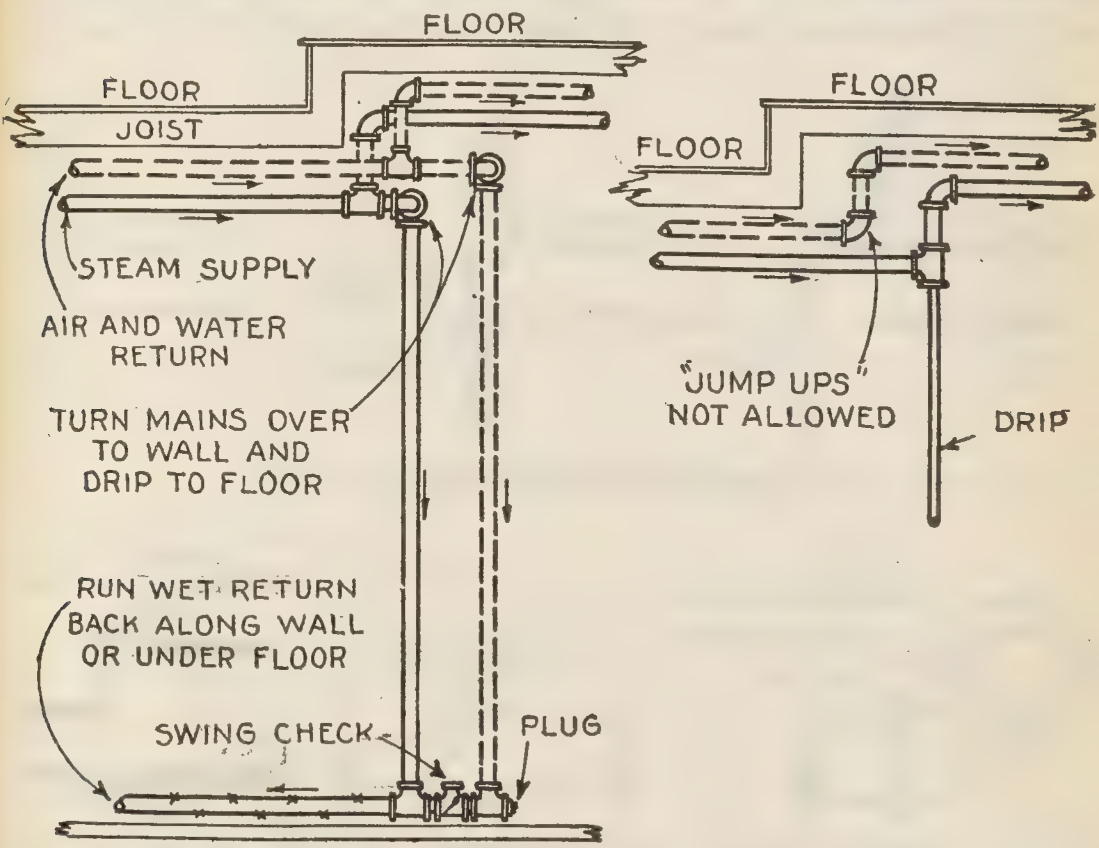


FIG. 8,553.—Correct method of rising to a higher level with drips into a wet return. No "jump ups" allowed without dripping as shown.

FIG. 8,554.—Improper methods.

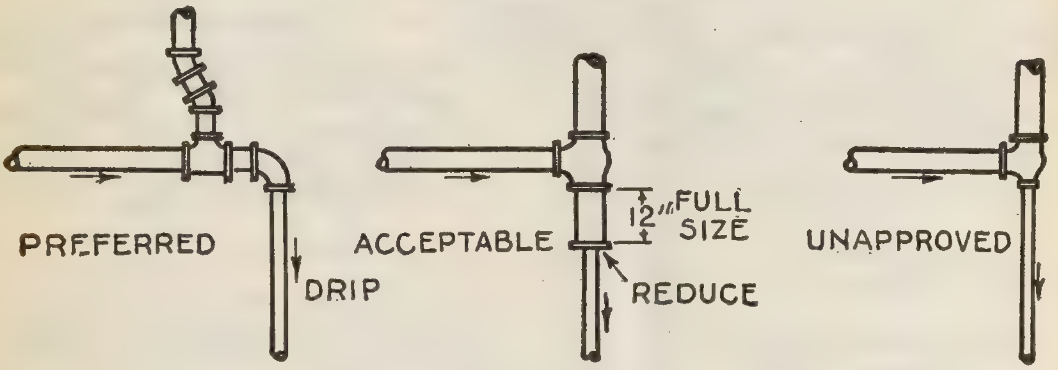
1. The difference between the temperature of the steam or water in the radiator and that of the air.

2. The velocity of the air passing over the radiator.

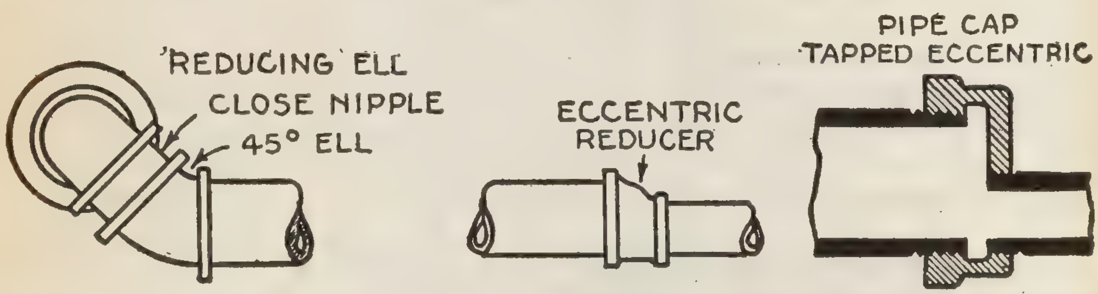
Under ordinary conditions, the indirect radiator will give off 2 heat units per hour for each degree difference in temperature

between steam or water and the air. In house work it is safe to figure from 400 to 420*B.t.u.* for steam and from 300 to 350*B.t.u.* for water per square foot of surface per hour. In school house work, owing to larger volume and higher velocity of the air, the efficiency is calculated at about 600 heat units.

Size of Mains.—The steam main can be determined by taking the total amount of direct radiation to which add 25 per cent for



FIGS. 8,555 to 8,557.—Methods of rising with large mains to upper floors.



FIGS. 8,558 to 8,566.—Three ways of reducing eccentric. Fig. 8,558, used at turns; figs. 8,559 and 8,560, used on straight runs.

piping, and from this total extract the square root, dividing same by 10, which gives the size of main to use. This is for one pipe work. For two pipe work, one size less is sufficient, and the return can be one or two sizes less than the supply. A steam main should not decrease in size according to the area of its branches, but very much slower.

Example.—Having 500 feet of direct radiation add to it 25 per cent or 125, which equals 625. The square root of this is 25, which divided by 10 gives 2½, or the size of the pipe. For handy reference and practical use the following table can be used, though not exactly in accord with the foregoing.*

Size of Steam Mains

Radiation	One-pipe work	Two-pipe work
125 square feet	1½ inch	1¼×1 inch
250 " "	2 "	1½×1¼ "
400 " "	2½ "	2 ×1½ "
650 " "	3 "	2½×2 "
900 " "	3½ "	3 ×2½ "
1,250 " "	4 "	3½×3 "
1,600 " "	4½ "	4 ×3½ "
2,050 " "	5 "	4½×4 "
2,500 " "	6 "	5 ×4½ "
3,600 " "	7 "	6 ×5 "
5,000 " "	8 "	7 ×6 "
6,500 " "	9 "	8 ×6 "
8,100 " "	10 "	9 ×6 "

Sizes of Hot Water Mains

Radiation	Pipe
75 to 125 square feet	1¼ inch
125 " 175 " "	1½ "
175 " 300 " "	2 "
300 " 475 " "	2½ "
475 " 700 " "	3 "
700 " 950 " "	3½ "
950 " 1,200 " "	4 "
1,200 " 1,575 " "	4½ "
1,575 " 1,975 " "	5 "
1,975 " 2,375 " "	5½ "
2,375 " 2,850 " "	6 "

In hot water, flow mains may be reduced in size in proportion to the branches taken off. They should, however, have as large area as the sum of all branches beyond that point. It is advisable that the horizontal branches be one size larger than the risers. Returns should be same as flows.

*NOTE.—As recommended by the William Page Boiler Co., New York.

Ventilation.—The respiration of one adult person will vitiate hourly about 500 cu. ft. of air, to which should be added vitiation from other sources, such as moisture from the body, methods of illumination, etc., making a requirement of about

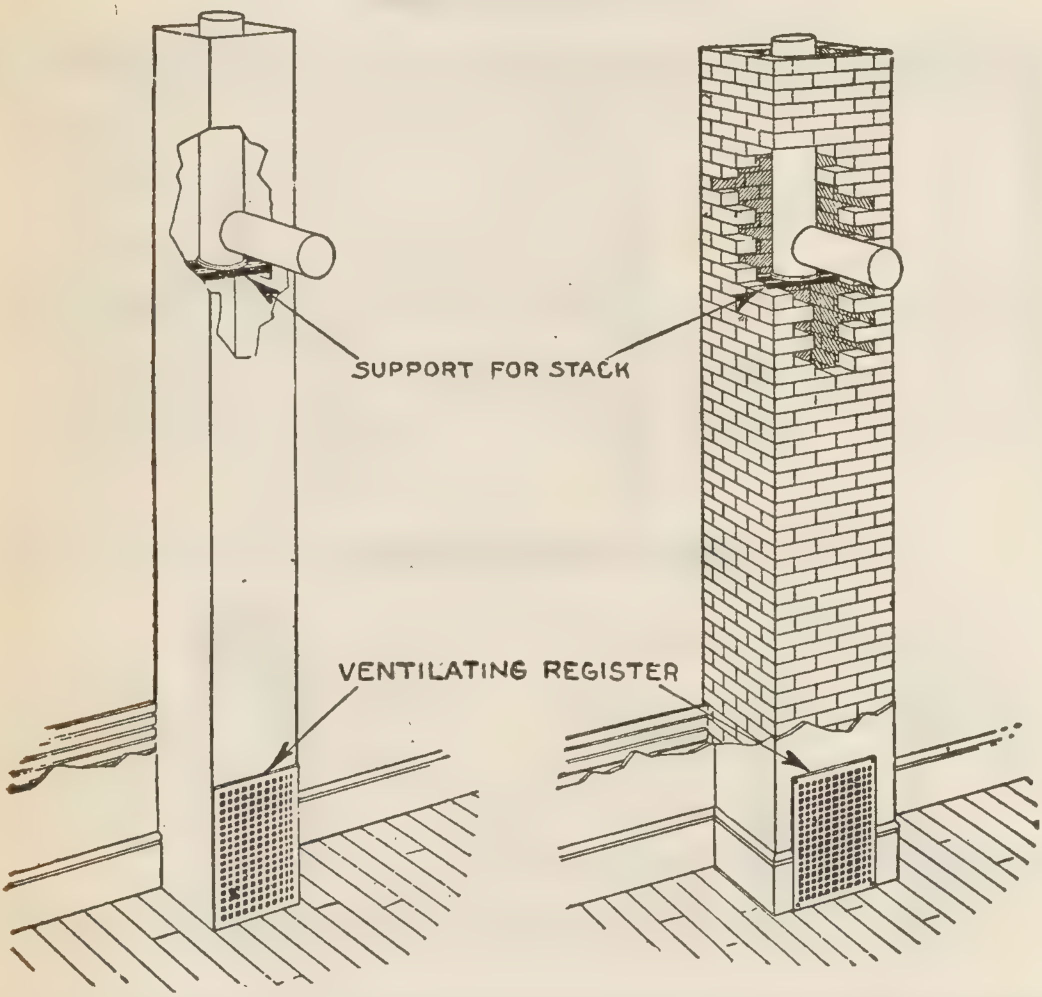


FIG. 8,561.—Galvanized iron duct used in lieu of chimney, showing ventilating register and steel smoke stack.

FIG. 8,562.—Brick chimney with ventilating register at bottom and steel smoke stack as used in fig. 8,561.

1,000 cubic feet per hour of fresh air for each adult person in average living rooms and places of assembly.

The atmosphere of rooms is changed partly by diffusion, but chiefly and effectively by positive currents, the supply of fresh

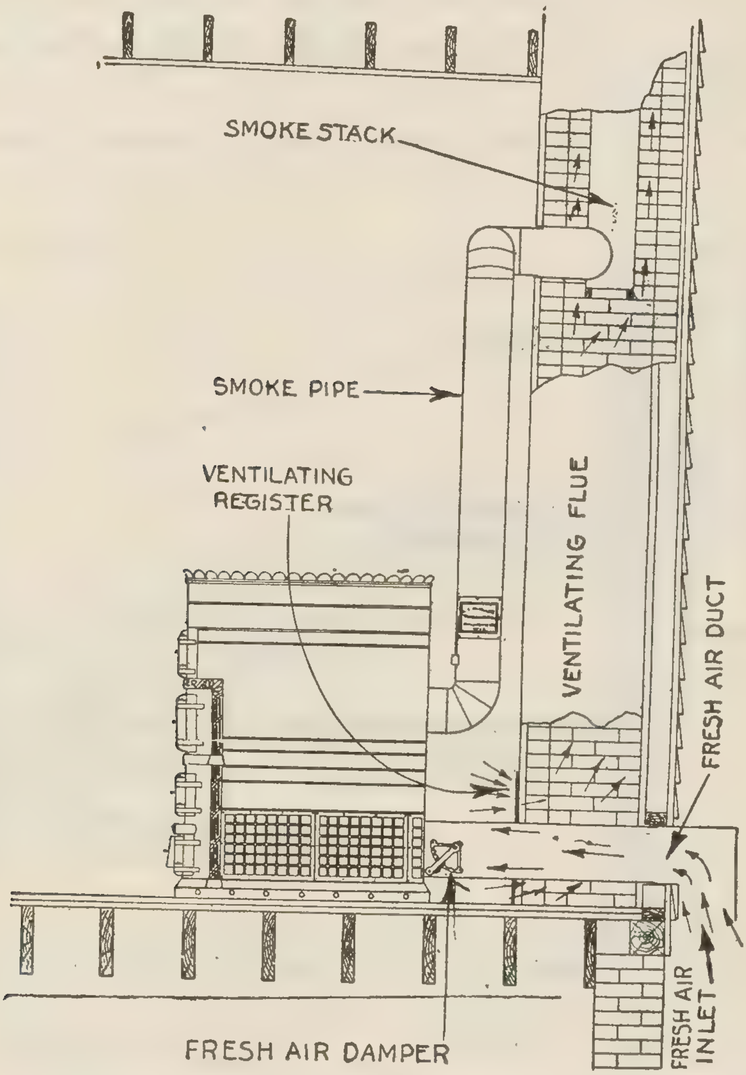


FIG. 8,563.—Mueller hot air furnace installation showing vent flue and fresh air duct. The cold air near the floor is drawn through grills at bottom of heater casing into the air chambers where it is heated. In the case of halls, schools, etc., at night and in fact at all times pupils are not assembled the outer air supply should be shut off and the air supply taken entirely from the room, thus materially saving fuel.

air through registers, connecting with the outside and becoming warmed as it passes over and through the intervening radiators

and the discharge of the foul air into flues provided for it. A common and most effective means in domestic ventilation is the chimney, through an open fire place, or a special flue in proximity to it is rendered most effective by the incident heat of the chimney. The opening to this flue should be at the bottom, practically on a line with the floor.

The fresh air from the outside passes through registers at a

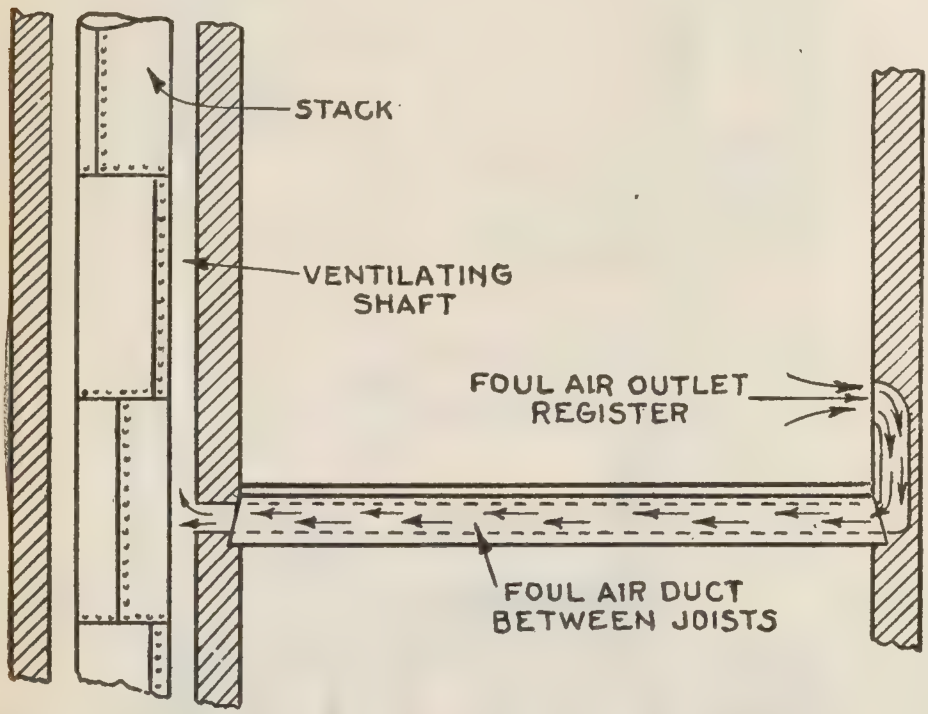


FIG. 8,564.—Method of connecting foul air duct between joists to ventilating shaft.

velocity from 200 to 300 feet per minute. The clear openings of a register will be approximately two-thirds of its full area; thus a 12 by 15 register would have an available area of 120 inches. The fresh, warm air, passing at this rate per minute, would supply from 10,000 to 15,000 cubic feet an hour, and meet the requirements of a family of from 10 to 15 persons.

The requirements of Massachusetts Laws in the ventilation of school

rooms is 30 cubic feet of fresh air per minute for each pupil. Thus, the average room providing for 50 pupils would require 1,500 cubic feet per minute, or 90,000 cubic feet per hour. Contemplating a movement of the air at the rate of 5 feet per second, and supply and exhaust registers—2 by 2½ feet each—or an area of 5 square feet will insure the desired result.

For churches and general assembly halls, the requirement is 15 cubic feet per minute for each person.

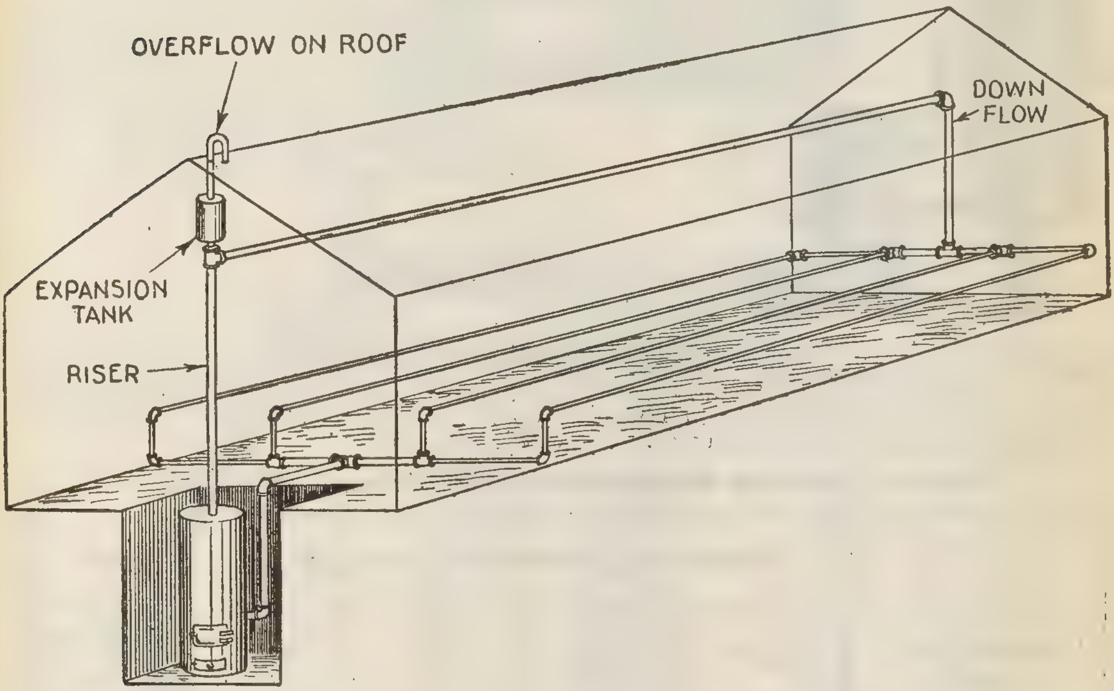
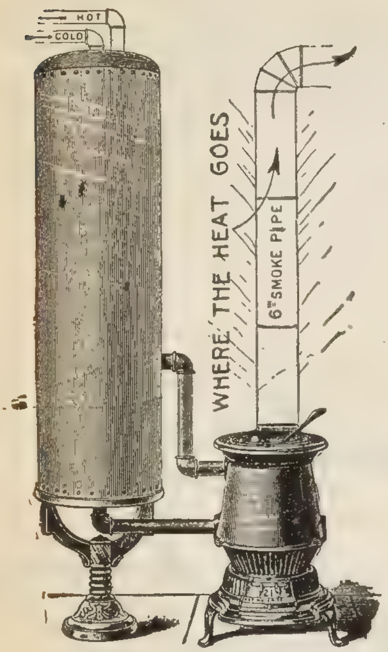


FIG. 8,565.—Overfed water heating system for green house. ***In this system*** the hottest pipes being in the most exposed portions of the house, the cold air, which finds entrance through or around the ventilators or through the laps in the glass, is tempered, thus tending to a nearer uniform heating effect. The expansion tank is placed above the high point of the system, and for which there should be pitch along the upper pipes and returns to facilitate circulation and allow for proper drainage.

Green House Heating.—In heating green houses, glass or its equivalent is the only factor considered. If amount of glass be not known, multiply the length of the house by its breadth and add ⅓ to get glass surface; ⅓ equals the ends and pitch of roof. Reduce wall surface to glass equivalent by dividing by 4 and



add to the glass surface. The heating surface required will be found by dividing this total glass equivalent by the factors in the following table by John J. Hogan:

This table is computed for zero weather; for lower temperatures add 1½% for each degree below zero. A green house requiring 200 feet of surface at zero should have 230 square feet at 10° below zero.

FIG. 8,566.—Usual method of setting up a heating stove to a range boiler. These "heating" stoves cannot be too strongly condemned unless one wishes to employ a long length of stove pipe to heat the room. The efficiency of this method of heating water, even with the low rate of combustion ordinarily employed is very low because a ridiculously small amount of heating surface is provided in proportion to the grate area.

Heating Surface Factors for Green House Heating

Temperature of air in house	Temperature of water in heating pipes				Steam
	140°	160°	180°	200°	Three lbs. pressure
	Square feet of glass and its equivalent proportion to one square foot of surface in heating pipes or radiator.				
40°	4.33	5.25	6.66	7.69	8.
45°	3.63	4.65	5.55	6.66	7.5
50°	3.07	3.92	4.76	5.71	7.
55°	2.63	3.39	4.16	5.	6.5
60°	2.19	2.89	3.63	4.33	6.
65°	1.86	2.53	3.22	3.84	5.5
70°	1.58	2.19	2.81	3.44	5.
75°	1.37	1.92	2.5	3.07	4.5
80°	1.16	1.63	2.17	2.73	4.
85°	.99	1.42	1.92	2.46	3.5

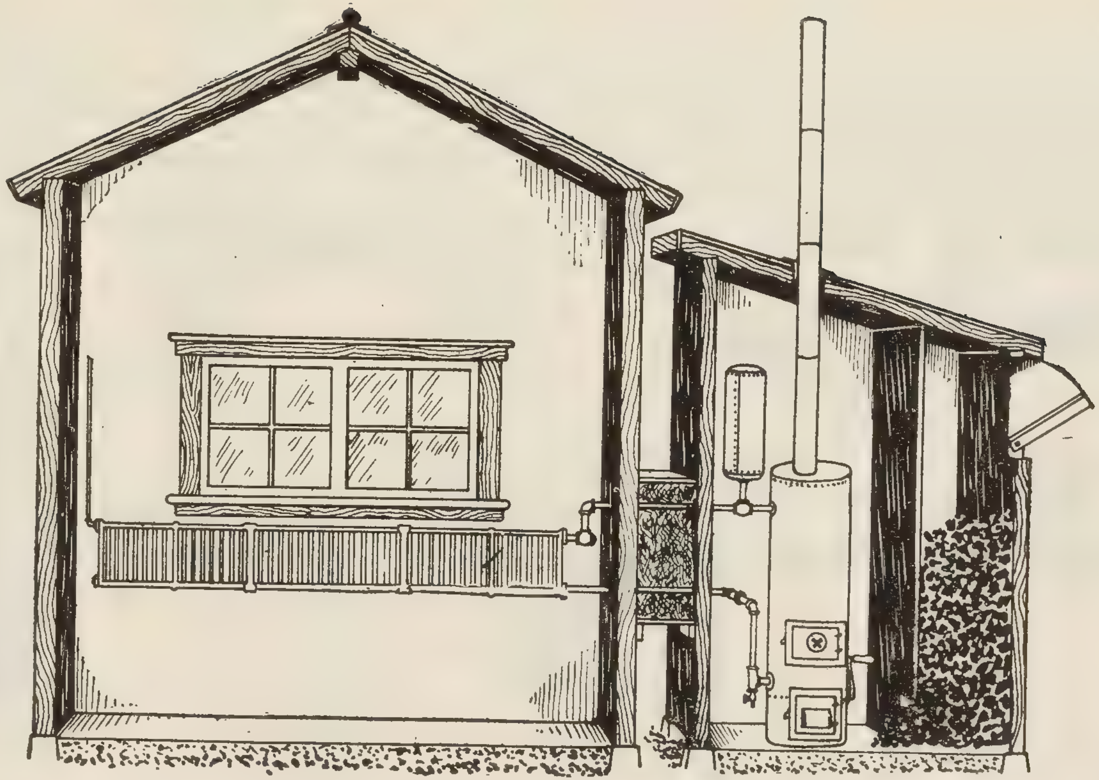


FIG. 8,567.—Small hot water heating installation for a garage. ***In many cities*** and communities the fire laws and regulations will not permit of an open fire in the same room with the car. The majority of fire insurance policies also prohibit the presence of a naked flame where there is a quantity of gasoline. To meet such requirements the boiler may be placed in an outside small building as shown, or in a "lean to," The circulating pipes when the boiler house is separate are protected from exposure to the elements by a simple boxing filled with insulating material. Where there is any regard for fuel economy a vertical tubular boiler will be installed (as here shown and more in detail on page **2,304**), rather than the coal eating rig shown on page **2,298**.

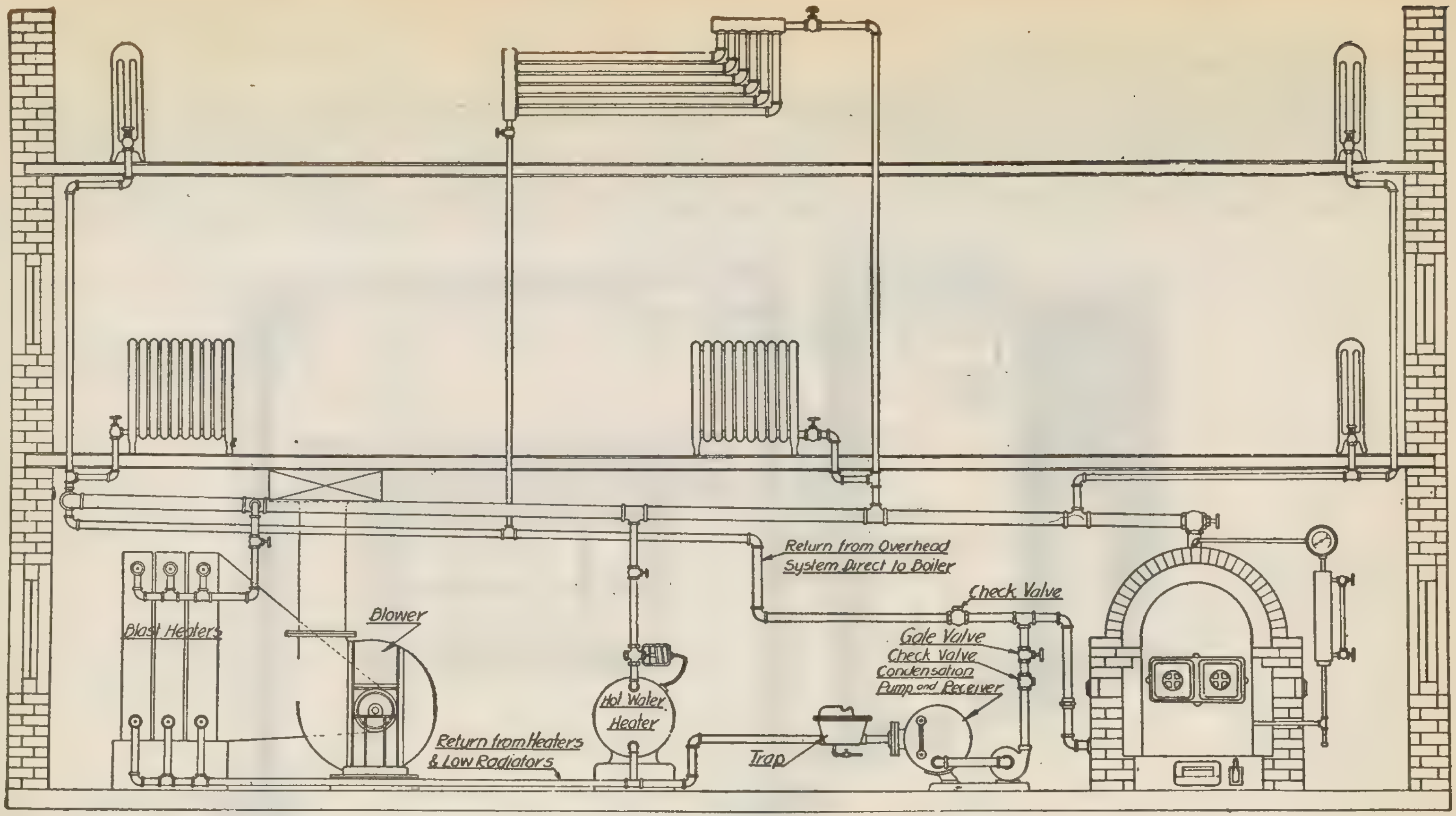


FIG. 8,568.—Economy Pumping Machine Co. pump and receiver, installation for steam heating system. ***Note:*** horizontal condensation pumps and receivers are suitable for use where the radiation is 12″-18″ above the floor or foundation upon which the pump is set. If the pump be installed in a pit, proper provision must be made for drainage and ventilating, as it is necessary to keep the motor absolutely dry. Vertical or underground pumps should be used for draining radiation close to or under the floor level. All condensation pumps and receivers must be selected to discharge against the pressure at which the safety valve is set, plus whatever allowance is necessary to overcome pipe friction and difference in level between boiler water line and pump. Frequently safety valves on heating boilers are set much higher than the normal operating pressure. All receivers are vented to the atmosphere, and are not ordinarliy designed for internal pressures. If steam enter the receiver with the condensate, it will be necessary to install a trap in the inlet to the receiver to prevent steam binding the pump.

***Capacity of Air Pumps.**—The capacity of air pumps or so called "vacuum pumps" to handle a given amount of heating surface, depends largely upon the character of the buildings. Thus, if the return mains be long, and the job spread out over several scattered buildings, a larger pump is required than if the same number of sq. ft. of radiation were all in one building several stories high. Again, the number of radiators, or units of heating surface, makes some difference, as a larger pump should be used where there are a large number of small units than would be necessary for the same amount of heating surface if divided into fewer, large units.

The table on the next page gives the standard sizes of air pumps with their average capacities in sq. ft. of heating surface. These capacities are for use where each coil and radiator is equipped with an automatic vacuum trap as in standard vacuum systems, as these traps and valves are necessary to prevent the vacuum pump pulling steam out of the heating system. The standard sizes given can be used where there is ordinary steam pressure, say 40 to 100 lbs. If the steam pressure be lower, it is necessary to use a pump with a large steam cylinder, or, if high pressure be carried at all times, a smaller steam cylinder may be used.

For instance, if a 5×7×10 pump would ordinarily be used, if steam pressure is to be low—10 to 20 lbs. it would be better to use a 6×7×10, or a 6×6×12 would give the same capacity and run on 10 lbs. steam pressure. Capacities are given in sq. ft. of direct heating surface, or lineal ft. of 1″ pipe in blast coils.

*NOTE.—The term ***vacuum pump*** is commonly and ignorantly used for ***air pump*** by those who do not understand the function of such pumps. The practice of some manufacturers in using the word vacuum instead of air is inexcusable, as they know better. *Water contains mechanically mixed with it 1/20 or 5% of its volume of air at atmospheric pressure.* When steam condenses, this air is liberated, that is, the condensate is free of air. Accordingly it must be evident that unless this air be removed as fast as it forms, the system would gradually fill with air. Hence the object of the air pump is to pump the air out of the system to permit the formation of a vacuum. There are two general types of air pump; 1, the *wet* air pump which removes both the air and condensate, and 2, the *dry* air pump which removes the air only.

Capacities of Air Pumps

Dia. Steam Cylinder		Dia. vacuum Cylinder		Stroke	Capacity in sq. ft.
4 "	×	4"	×	5"	2,000
4 "	×	6"	×	7"	3,000
4½"	×	6"	×	8"	5,000
5½"	×	8"	×	7"	6,000
5 "	×	7"	×	10"	7,500
5 "	×	8"	×	10"	10,000
6 "	×	9"	×	10"	15,000
6 "	×	8"	×	12"	20,000
8 "	×	10"	×	12"	35,000
8 "	×	12"	×	12"	50,000

CHAPTER 125

Steam Heating Boilers

The conditions under which a boiler works in furnishing steam for heating buildings are quite different from those encountered in a power plant, hence, as might be expected, the construction of a heating boiler is quite unlike that of a power boiler.

The chief points to be considered in design are:

1. Very low steam pressure;
2. Low rate of combustion;
3. Long intervals between firing;
4. Automatic draught control;
5. ***Adequate*** *heating surface.*

Accordingly the construction need not be so substantial to resist internal pressure, as for power boilers, thus permitting the use of cast iron.

Most heating boilers are built in sections of cast iron making a very durable construction.

By building up a boiler from cast iron sections, the size may be varied considerably according to the number of sections used, thus a multiplicity of sizes is obtained without requiring numerous patterns. While this reduces the cost of manufacture, it results in numerous instances of boilers not properly proportioned for economy, especially in the vertical types.

25:1

The Heating Surface.—The author after a laborious examination of about one hundred boiler catalogues found that while nearly all gave the grate area, very few gave the area of heating surface (for obvious reasons).

While, for example, he found that in one size of the Vance boiler 38 square feet of heating surface per square feet of grate is

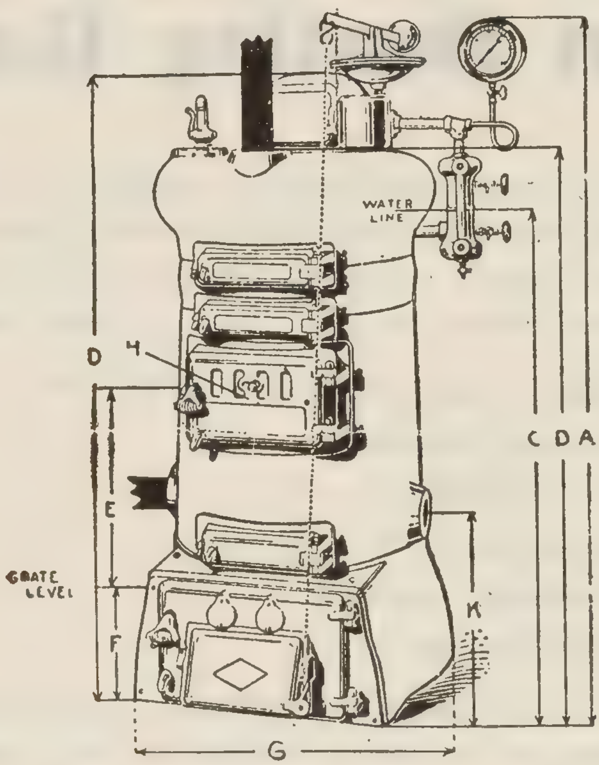


FIG. 8,569.—Typical round vertical boiler showing general exterior appearance and fixtures.

provided, in another make boiler (the name ought to be printed in large letters) only 8.3 square feet of heating surface is provided per square foot of grate. Of course, if coal cost nothing, or the coal dealers paid for the privilege of delivering it to your door, such allowance of heating surface might suffice, ***but***

where there is any regard for economy an ***adequate amount*** *of heating surface will be provided.*

Although the low rate of combustion in a heating boiler permits a lower ratio of heating surface to grate area than in power

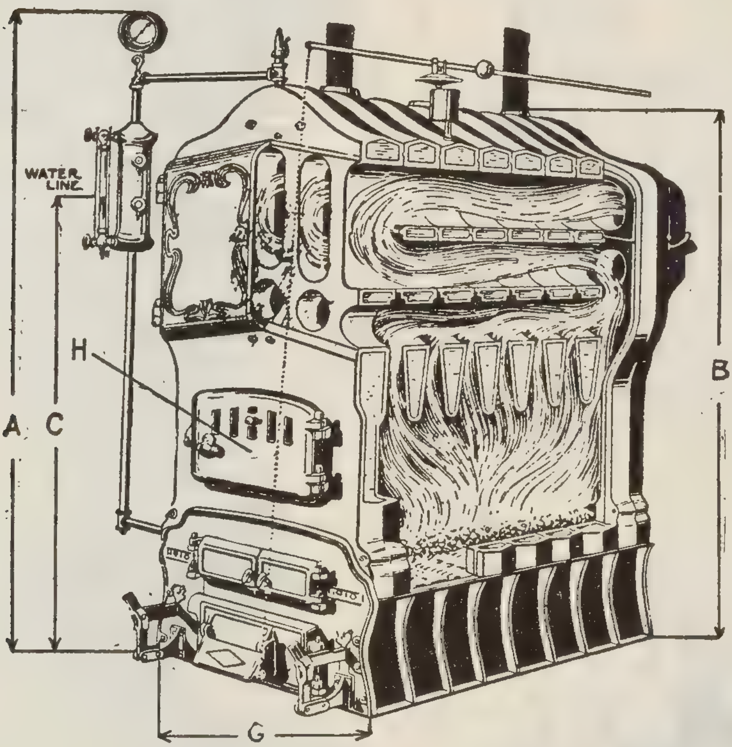
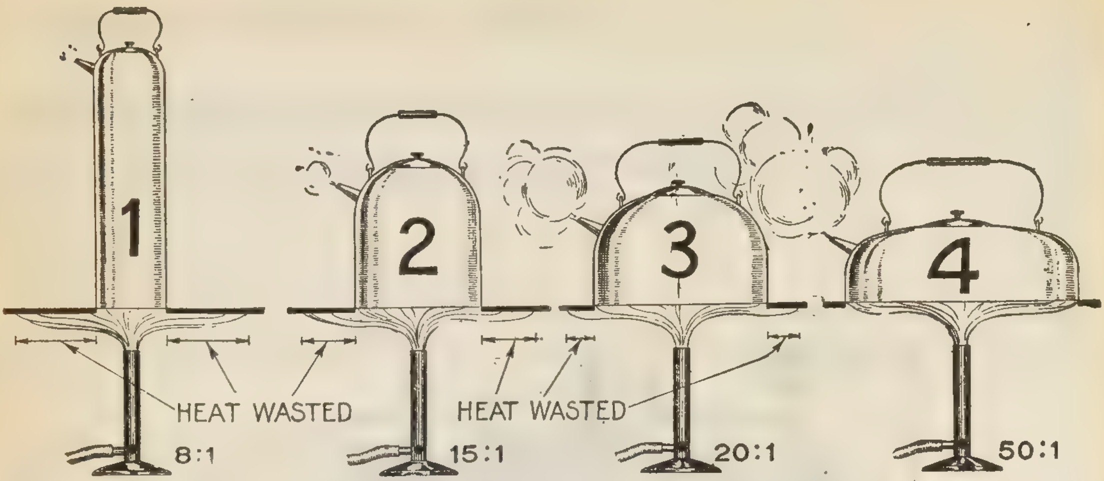


Fig. 8,570.—Sectional view of typical horizontal boiler showing sections and passages for the flow of the hot gases.

plant boilers, no such ridiculous ratio as 8.3 to 1 should be used under any circumstances.

The usual construction of a vertical sectional boiler comprises a base section containing the grate, a fire pot with space all around for the water, and piled up on the top of this is one or more



FIGS. 8,571 to 8,574.—Effect of inadequate heating surface. This may be illustrated by taking several kitchen hot water kettles of equal capacity, but of different diameters, so that the area of the bottom or part exposed to the fire (heating surface) will say 8, 15, 20, and 25 square inches. Put the same quantity of water into each and place under each a bunsen burner whose tip has an area of 1 square inch. When the burners are lit (assuming equal flames) it will be noticed that only a very small portion of the flame will touch the bottom of kettle No. 1, more will come in contact with No. 2, still more with No. 3, and all with No. 4. The result is that No. 4 will begin to boil first, No. 3 next, then No. 2, and last No. 1. Evidently it takes less fuel to heat No. 4 than any of the others, the waste being about in the proportion indicated by the arrows. *The same thing happens in a house heating boiler*. Don't blame the manufacturers because there are a lot of boilers like kettles Nos. 1 and 2 on the market—*it's* ***your fault***. If you thought less about first cost, and more about your coal bills you would buy a boiler like No. 4 kettle, and the cost of coal wouldn't be so high.

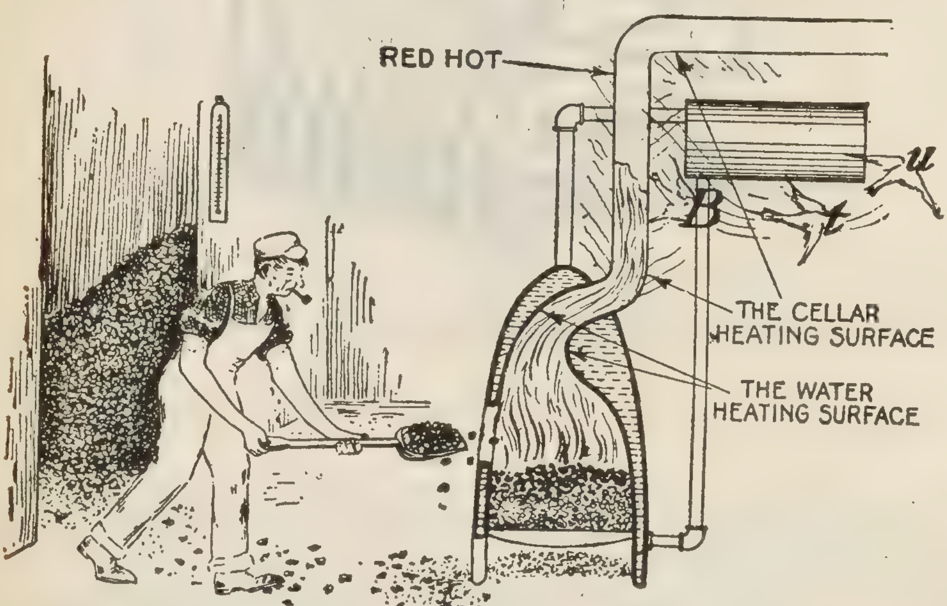
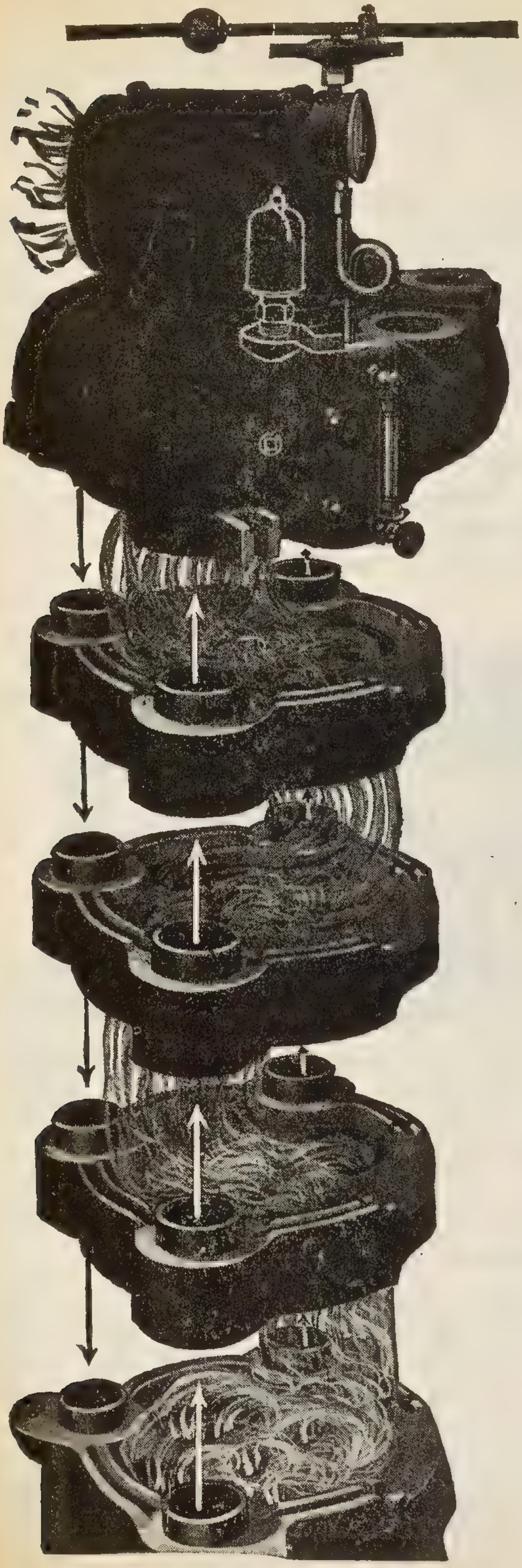


FIG. 8,575.—The principal reason why the tenants get no hot water. It's not the fault of the manufacturer, he simply builds what the public is willing to pay for and does not worry about the coal bills.



intermediate "sections," and a top or dome, thus several sizes of boilers are listed all having the same size grate.

Evidently the efficiency of such apparatus will depend principally upon the number of sections or amount of heating surface piled up over the furnace and the arrangement of these sections. Accordingly if the purchaser be interested in economy of fuel, he will select a boiler which has an adequate amount of heating surface in proportion to the grate area, and especially in view of the ever increasing cost of fuel the ratio of heating surface to grate area should not be less than 25 to 1.

Rate of Combustion.—In steam boilers for power plants which receive constant attention, coal is generally burned at from 10 to 30 pounds per square foot of grate per hour. However, in heating boilers, the conditions are different. There is no fireman in constant attendance, the practice being to dump on the grate a considerable quantity of coal sufficient to last 6 to 8 hours at a low rate of combustion. This requires a deep fire pot to hold the considerable depth of fuel.

FIG. 8,756.—International boiler parts showing circulation and travel of the hot gases.

For house heating boilers the standard combustion rate is taken at 4 pounds of coal per square foot of grate per hour, but for larger boilers such as used for large buildings where the firing is done more frequently the grates are proportioned for a higher rate.

According to the American Society of Heating and Ventilation Engineers: "The grate surface to be provided depends on the rate of combustion and this, in turn, on the attendance and draught, and on the size of the boiler. Small boilers are usually adapted for intermittent attention and a slow rate of combustion. The larger the boiler the more attention is given to it and the more heating surface is provided per square foot of grate."

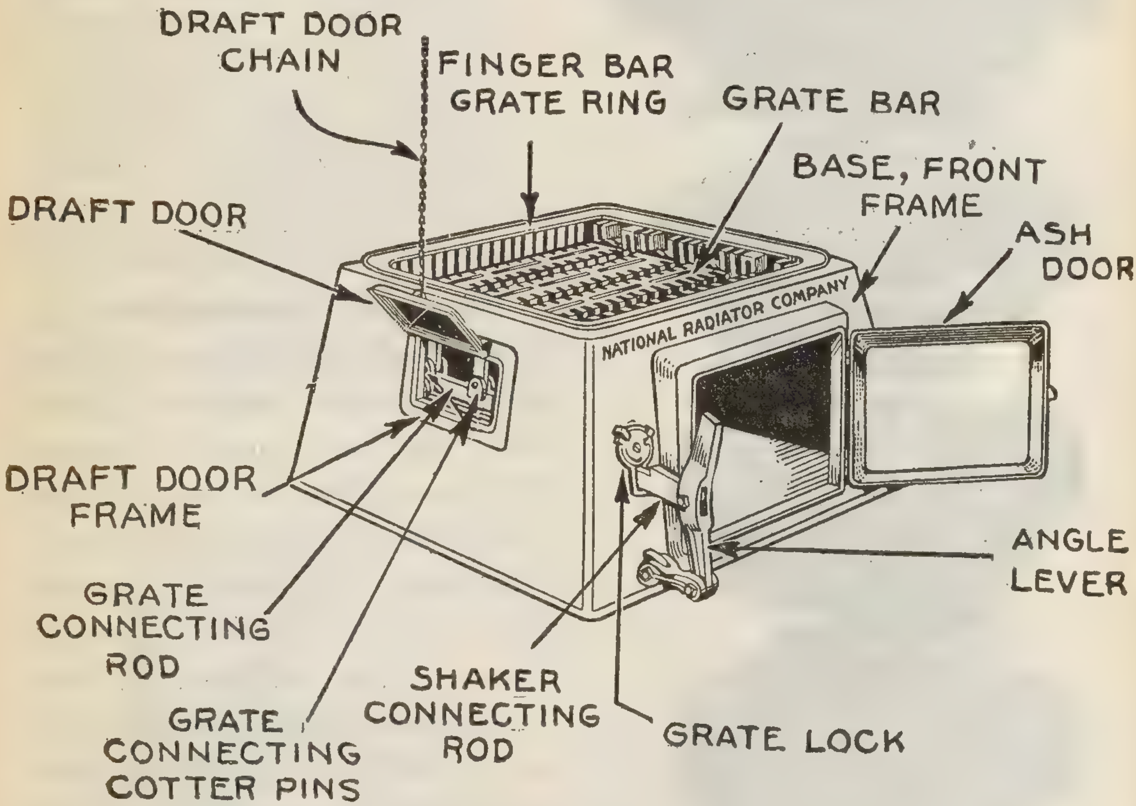


FIG. 8,577.—National square base with names of parts.

'The following rates of combustion are common for internally fired heating boilers":

Sq. ft. of grate..................	4 to 8	10 to 18	20 to 30
Lbs. coal per sq. ft. of grate per hour	4	6	10

The following table from Kent gives some proportions and results that should be obtained.

Proportions and Performance of Heating Boilers

	Low	Medium boiler	High boiler
1 square foot of grate should burn....	3	4	5 pounds coal per hour
" " " " " " develop .	30,000	40,000	50,000 *B.t.u.* per hour
" " " " " ***will require*** ...	***15***	***20***	***25 square feet heating surface***
" " " " " supply.........	120	160	200 square feet radiating surface

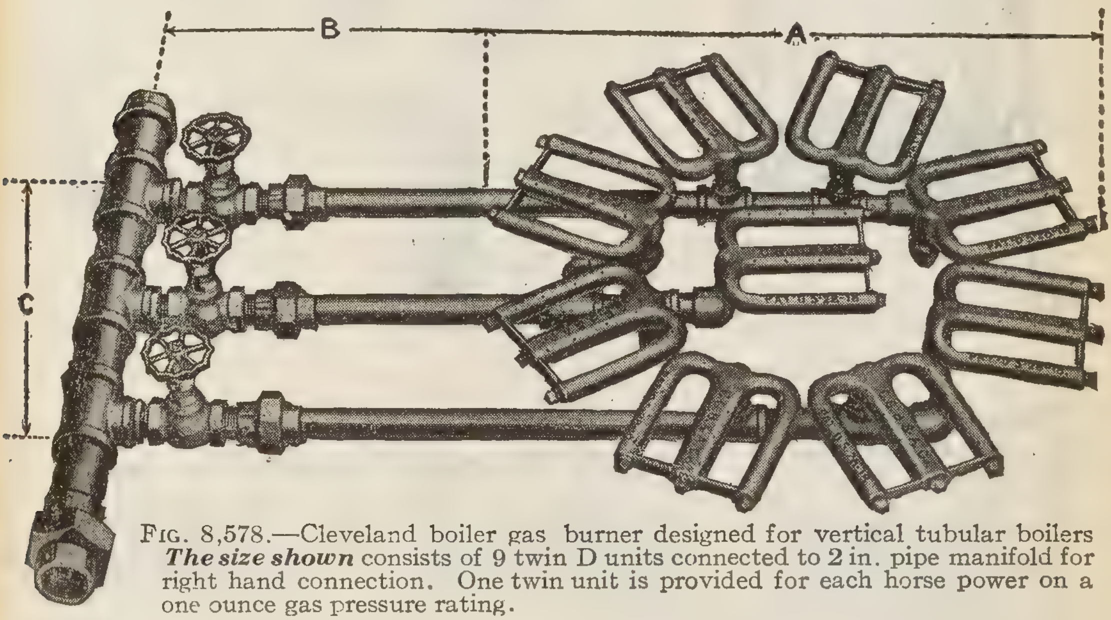


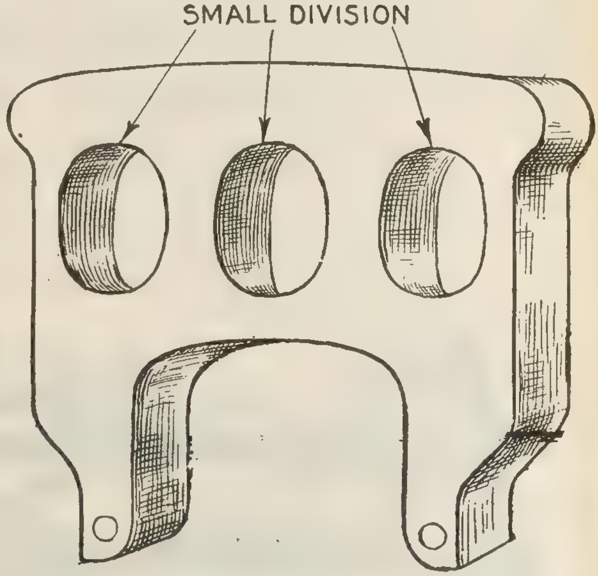
FIG. 8,578.—Cleveland boiler gas burner designed for vertical tubular boilers ***The size shown*** consists of 9 twin D units connected to 2 in. pipe manifold for right hand connection. One twin unit is provided for each horse power on a one ounce gas pressure rating.

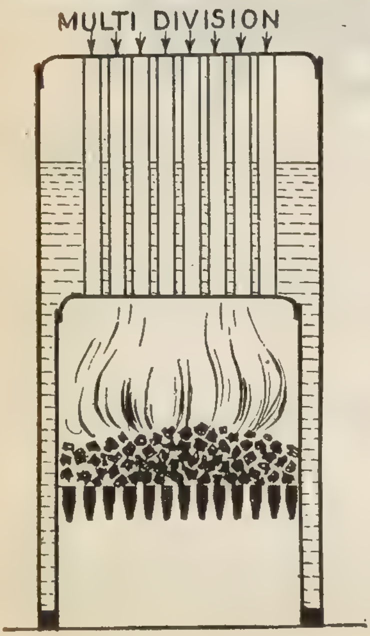
Points on Boilers.—In the selection of a boiler it is well to examine closely the details of construction. A good design should embrace the following features:

1. There should be ***not less*** *than* ***25*** *square feet of heating surface per square foot of grate area.*

If manufacturers would stop talking so much about "prime" or direct and indirect heating surface, and state the total amount of heating surface provided per square foot of grate, and its arrangement, the purchaser would be more enlightened, especially the better informed.

2. The passages through which the hot gases traverse the heating surface should be so arranged that they have the proper



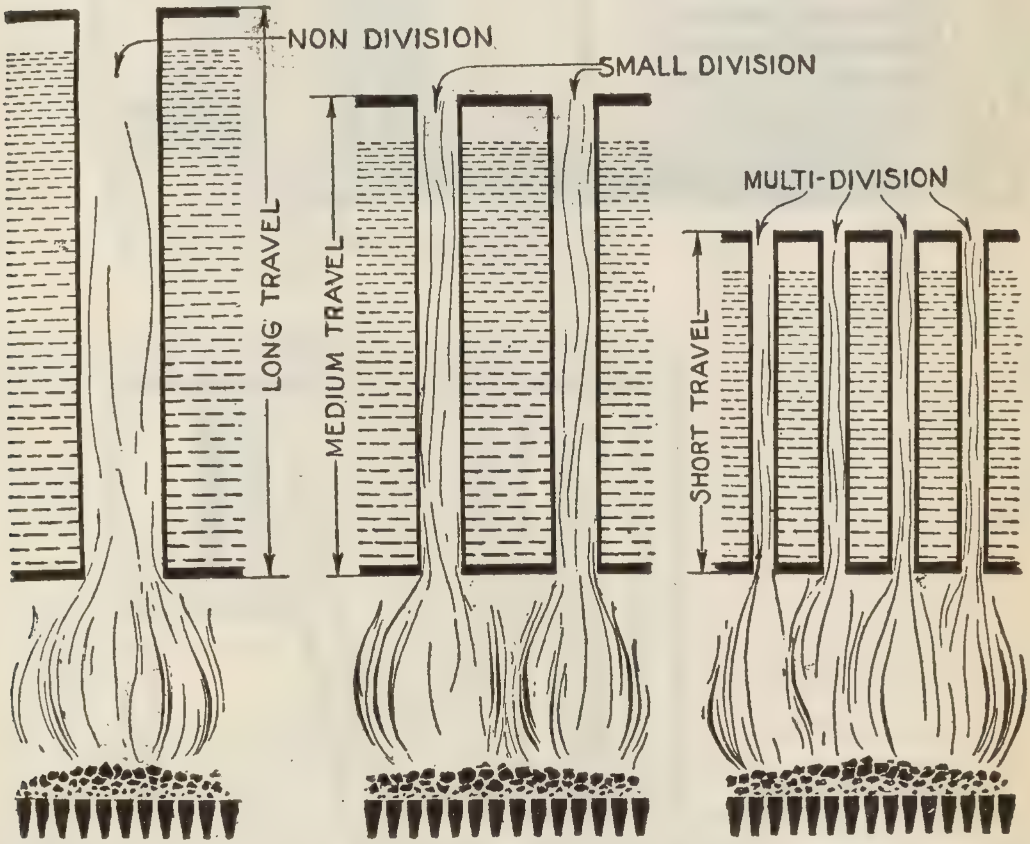


length of travel (guided by baffles or equivalent) and come in contact with all the heating surface, that is, short circuiting should be avoided.

The proper length of travel will depend on the *arrangement* of the heating surface. There are

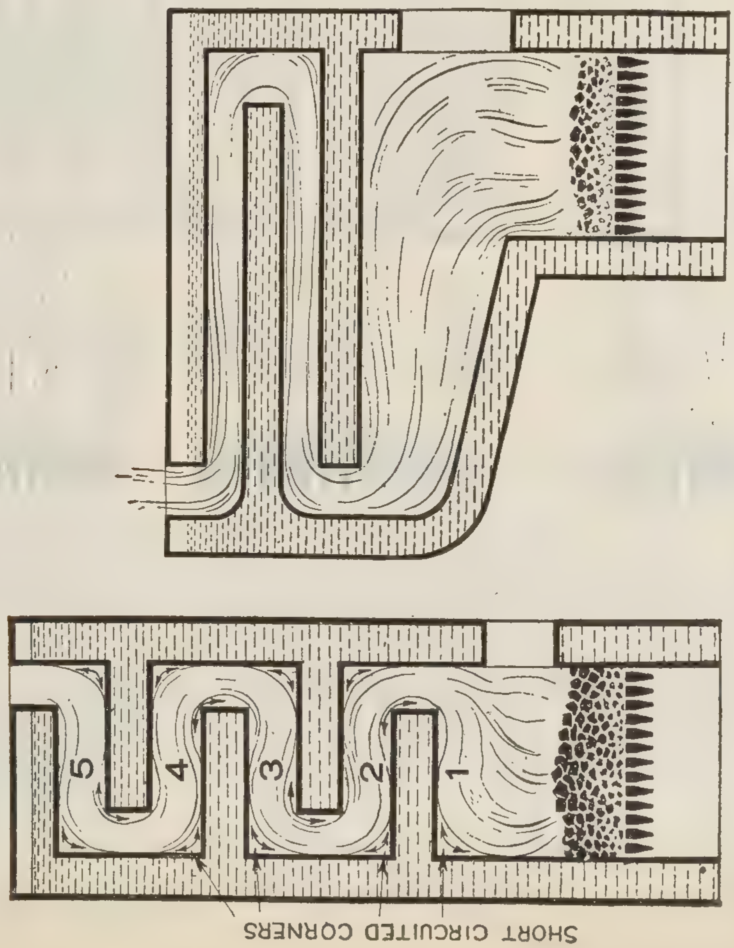
FIGS. 8,579 to 8,581.—Division of the hot gases. For equal travel of the gases over the heating surface the ***mono-divisional*** *arrangement of fig.* 8,579, *is* ***very wasteful.*** As the gases are split up into more divisions as in figs. 8,580 and 8,851 each being surrounded by heating surfaces, evidently (assuming adequate combustion chamber) more heat is absorbed and the stack temperature reduced, because the gases come into contact with a larger amount of heating surface per foot of travel. It follows then that *the* ***less*** *the division of the gases, the* ***longer*** *must be the travel of the gases,* for equal efficiency.

three cases, 1, ***non-division***, 2, small division, and 3, ***multi-division*** of the gases, as shown in figs. 8,582 to 8,584. Evidently the first arrangement requires a long pass for the gas to travel for proper absorption of heat, whereas with the second or third arrangement a short travel will suffice, the length of travel depending on the degree of division of the gases as shown in the figures.



FIGS. 8,582 to 8,584.—The efficiency of the heating surface does not depend on the length of travel, but on the ratio of the cross sectional area of the passage to its length and the arrangement or disposition of the surface with respect to the hot gases. In a vertical tubular boiler for instance there may be only one large and long tube as in fig. 8,582, and the temperature of the gases escaping at the end of the tube will assume a certain value depending upon the rate of combustion and the efficiency will depend on these values. The single tube of fig. 8,583 may be replaced by several smaller and shorter tubes as in fig. 8,583, or a still larger number of very small and very short tubes as in fig. 8,584, the ratio of length to diameter (or cross sectional area) being the same in each case, and there will not be any loss of efficiency. That is by properly proportioning the size and number of the tubes. Any length tube may be used without increasing the stack temperature.

3. For a given length of travel of the hot gases the efficiency of the heating surface decreases with the number of turns, as in figures 8,585 and 8,586.



FIGS. 8,585 and 8,586.—Characteristics of short and long pass boilers. For a given travel of the hot gases the shorter the passes the greater the number of turns where short circuiting occurs, hence the greater the proportion of the heating surface rendered inefficient. Accordingly for equal travel, ***a few long passes are more efficient than many short passes.***

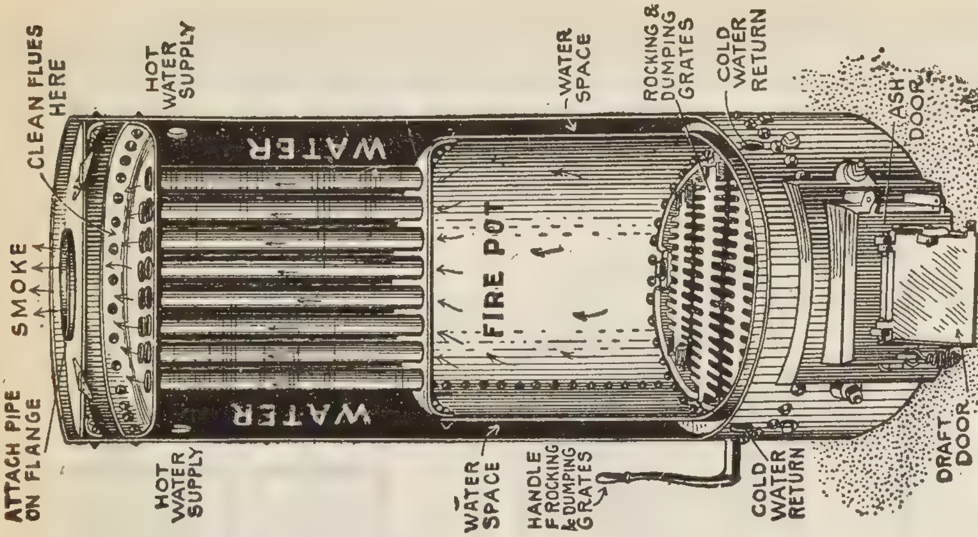
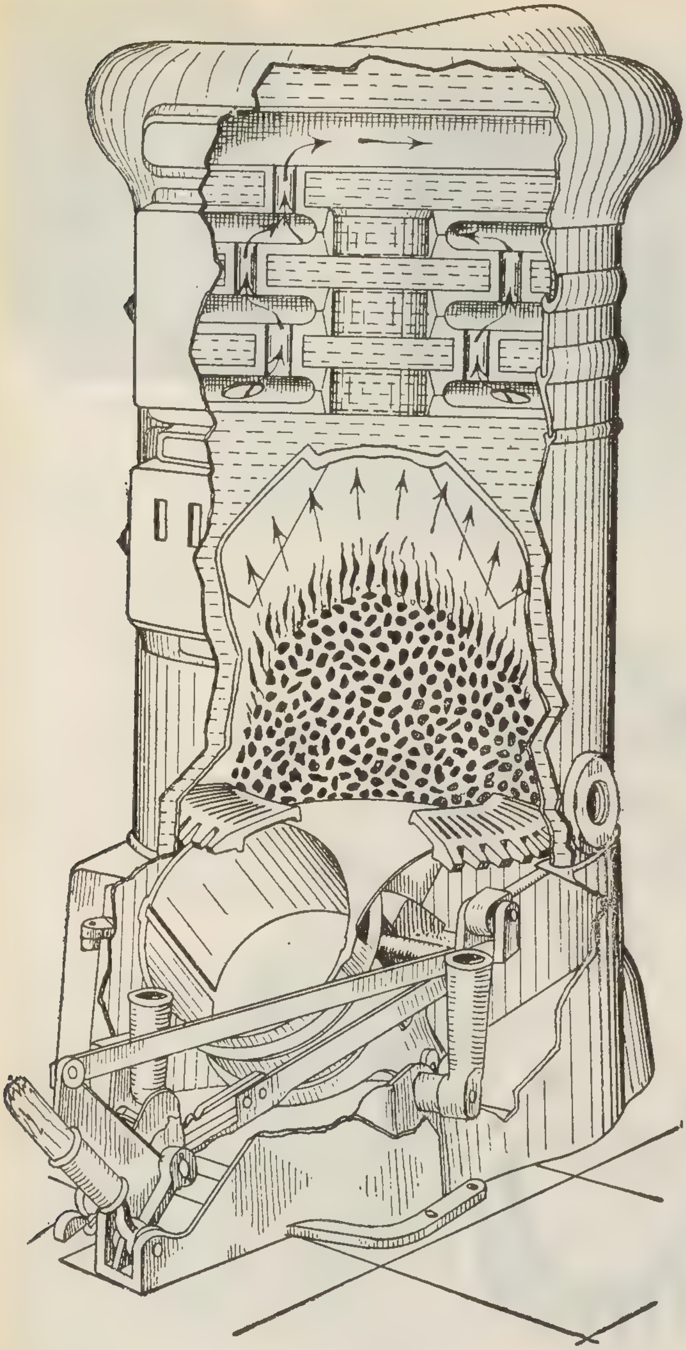


FIG. 8,587.—Andrews vertical tubular boiler; an example of ***multi-division*** of the hot gases giving a very effective form of heating surface.



Whenever the direction of flow is changed, centrifugal force causes the steam or hot gases to leave one surface and pile up on the other, short circuiting the abrupt corners.

4. The combustion chamber or fire pot should be large so as to obtain good combustion.

This involves for equal grate areas, and equal intervals between firings, a larger fire pot for high than for low combustion rates, in order to provide space for the larger charge of fuel at each firing.

5. The fire box should be proportioned according to the rate of combustion, and in the smaller sizes should have considerable depth below the fire door in order to hold sufficient charge for from 6 to 8 hours operation without attention.

FIG. 8,588.—Williamson underfeed boiler. ***in construction,*** there is connecting with the coal chute a funnel shaped hopper, with its feed opening outside of the boiler proper. By means of a piston, which slides in this coal chute, and a light, wooden lever, which operates the plunger, coal which has been placed in the hopper is easily pumped through the chute, up onto the grate and underneath the body of burning coal. The fire is pushed upward and outward, and the fresh coal is thus surrounded on all sides and the top by fire.

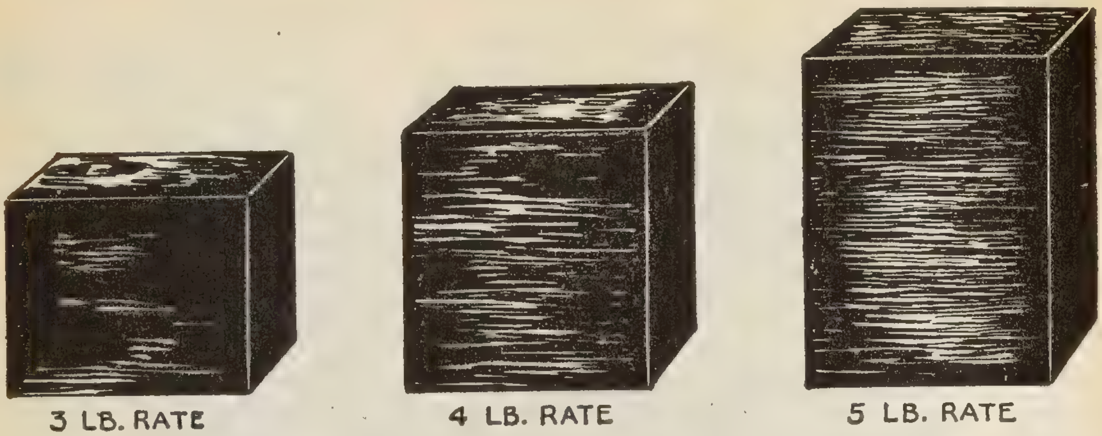
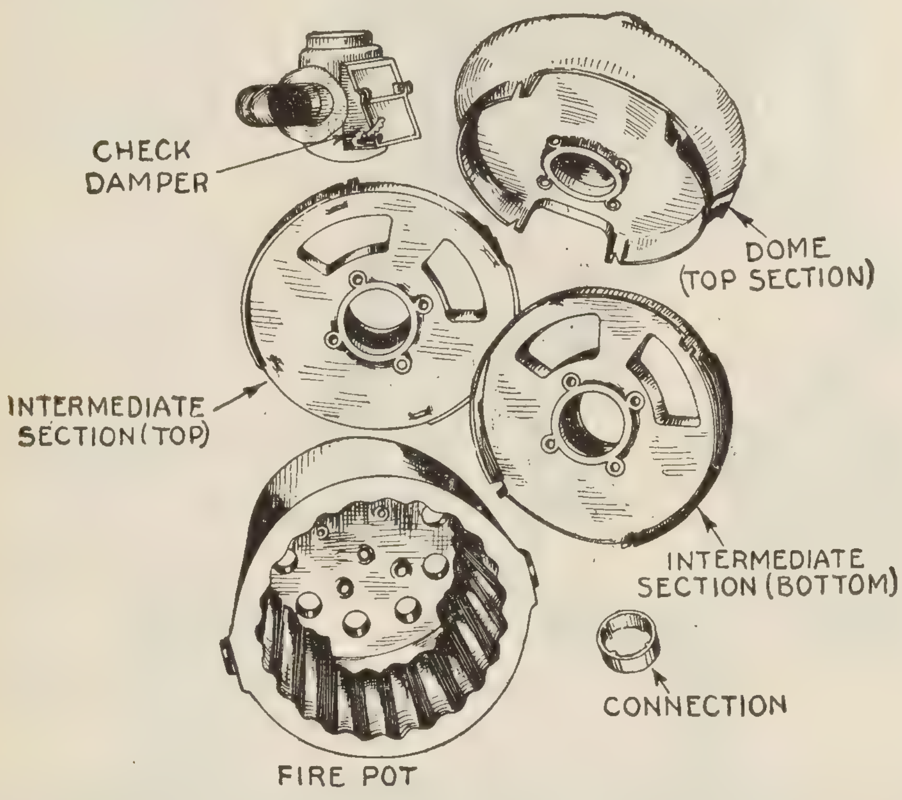


FIG. 8,589 to 8,591.—The depth of the fire pot should increase with the rate of combustion in order not to reduce the size of the combustion chamber. The figures show the relative amounts of coal thrown into the furnace at each firing for the 3-, 4- and 5-pound combustion rates with equal intervals between firings and equal grate area. Hence, *for different ratings on one side grate, the* ***higher*** *the rating the* ***deeper*** *should the fire pot be, to avoid decreasing the size of the combustion chamber.*



FIGS. 8,592 to 8,.597—Parts of Magee boiler above the base showing fire pot intermediate sections, dome, damper, and push nipple. ***In construction,*** the corner sheet is cast integral with the fire pot whose interior sides are corrugated to increase the heating surface. The parts are joined together by push nipples.

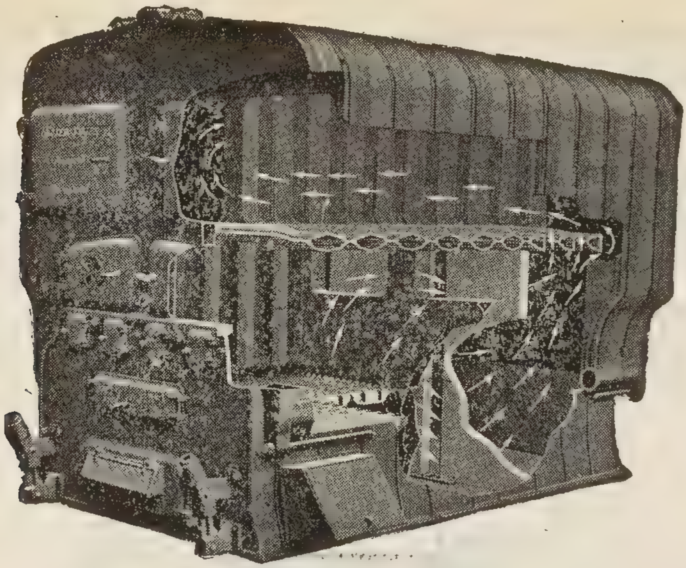


FIG. 8,598.—United States "Capitol" horizontal boiler showing mixing chamber and ignition wall. ***In operation,*** the volatile gases pass from the furnace into a mixing chamber through two horizontal openings at the top and in the back or bridge wall of the furnace. This mixing chamber back of the furnace is formed by the bridge wall at the front and an ignition wall of fire brick at the rear of the mixing chamber. Because of the continuous volume of burning gases pouring from the furnace through the bridge wall and against this ignition wall it is constantly maintained at a temperature of approximately 1,600 degrees or about 400 degrees above the ignition point, the temperature at which these gases burn. All the gases from the furnace must pass through this mixing chamber, and while they enter the mixing chamber through two horizontal openings, their escape from the mixing chamber to the combustion chamber at the rear of the boiler is through a long vertical opening in the ignition wall, the area of which is slightly less than the area of the two horizontal openings into the mixing chamber. It is claimed that the effect of this arrangement is a congestion and intermixture of burning gases within the mixing chamber in contact constantly with the ignition wall, which is maintained at a temperature above the ignition point of the gases.

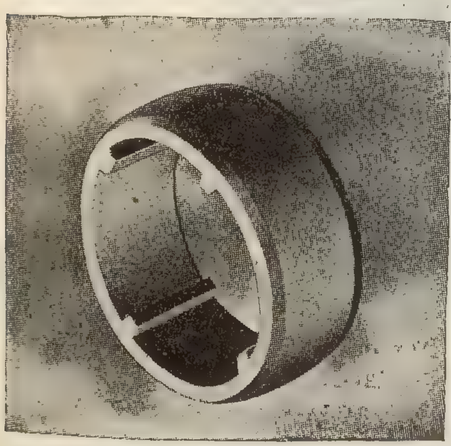


FIG. 8,599.—Push nipple used to join together sections of cast iron boilers. The nipple is accurately machined and has a slight taper so that when forced into the opening in the sections, by drawing the sections together by means of a rod a tight joint is obtained.

FIG. 8,600.—Gilt Edge water back attachment for hot water supply.

6. There should be a wide door at the level of the grate and just high enough to permit removing clinkers; it is called the slice door.

7. The grate should be of the shaking and dumping type, easily accessible for repairs, and of a standard make so that duplicate parts may be obtained.

8. The ash pit should be large and *deep* so that it will hold a large quantity of ashes.

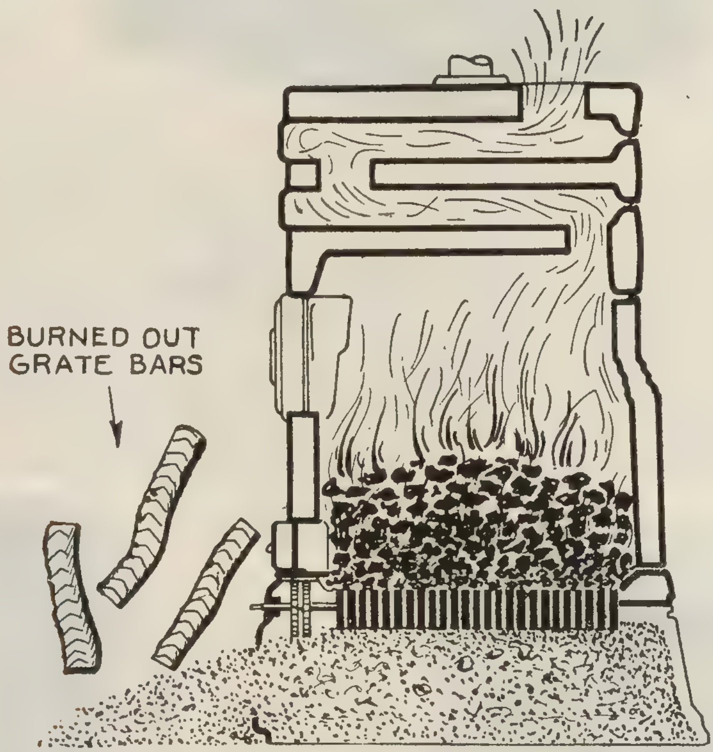


FIG. 8,601.—Usual condition of the ash pit when the owner cannot put off taking up the ashes any longer. Note the burned out grate bars due to letting ashes accumulate in the ash pit. The illustration does not show the new grate just ordered from the plumber, but it is on the way.

With the inferior and careless attention (or rather non-attention) usually given to house heating boilers, ashes are allowed to accumulate until they are flush with the grate bars and are then only removed because they interfere with the draught. Of course, where the owner does his own firing and can stand the expense of frequent grate renewals, he may adopt this method of handling the ashes.

9. There should be a positive circulation of water and sufficient liberating surface and steam space provided to prevent priming or unsteady water level.

10. The ratings of heating boilers as given in manufacturers' catalogues may be as a rule safely accepted, but the efficiency of the apparatus should be seriously questioned.

*The **amount** and **arrangement** of the heating surface, **size** of combustion chamber and **grate area** should be thoroughly investigated.*

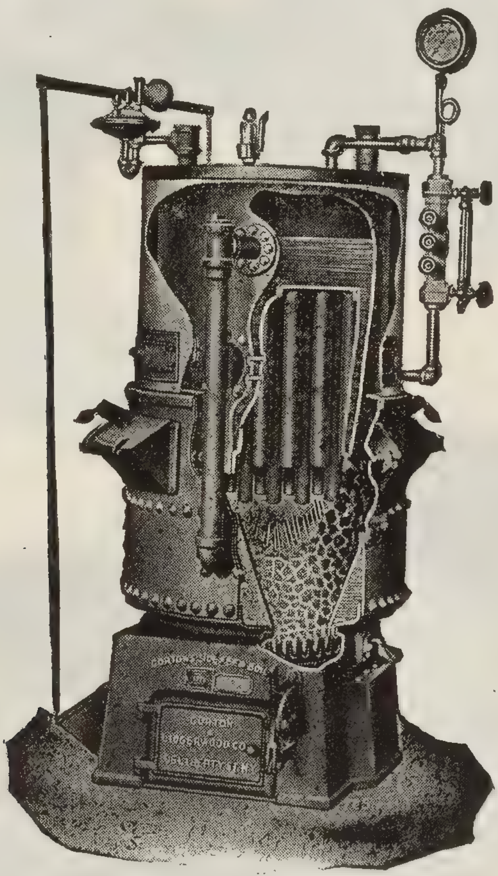
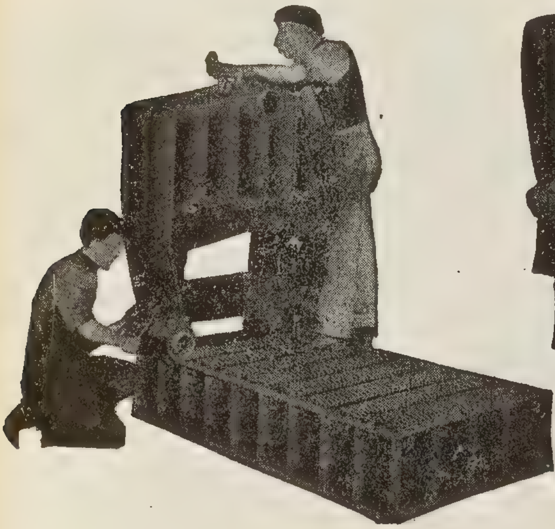
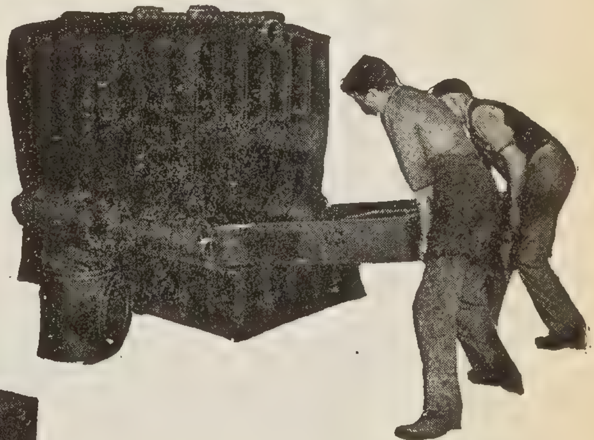


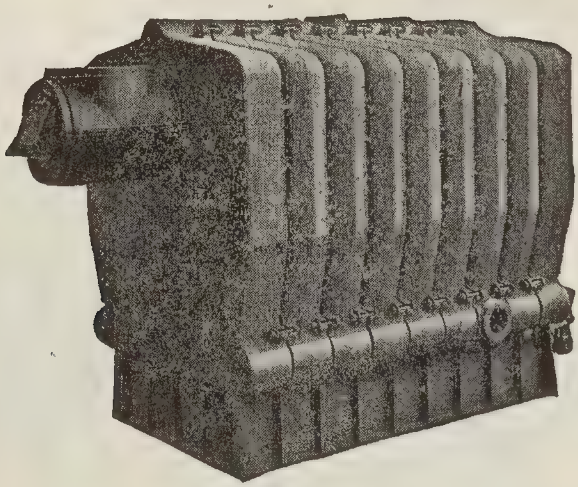
FIG. 8,602.—Gorton drop tube magazine feed vertical boiler, designed especially for soft coal. ***In construction,*** the boiler is made in two parts, the tubular part, or boiler shell, is directly over the fire, and the lower part, or the water leg, surrounds the fire. They are connected together by the two circulation pipes, one in the front and one in the back of the boiler. The lower part of the shell extends down into the upper part of the water leg, and the space between the shell and the water leg is used for the coal reservoir and coking chambers. The reservoir is divided into four compartments, which form the coking chambers, in which the coal is coked. The fire pot is so constructed that sufficient additional air is drawn through the ring at the lower edge of the coking chambers to ignite the gases arising from the coking process, giving good combustion.

Figs. 8,603 to 8,609.—Method of assembling a horizontal boiler. First comes the base, fig. 8,603. It is in four main pieces which are bolted together; fig. 8,604, the grate bars are dropped into their sockets; fig. 8,605, fastening grate shaker connections, the grate is tested by shaking;

Construction Details.—A large proportion of the small and medium size boilers are made of cast iron. This material not only being very durable, but lends itself to flexibility of design, the sectional method of construction permitting boilers to be shipped, knocked down and carried through narrow openings in buildings.







Figs. 8,603 to 8,609—*Continued.*

the back half is being operated fig. 8,605; the first section is lifted on and slid into place fig. 8,606; push nipples are inserted and another section placed in position;fig. 8,607; the four tie bolts are then tightened; in the last section is being put in position fig. 8,608, and boiler erected is shown in fig. 8,609.

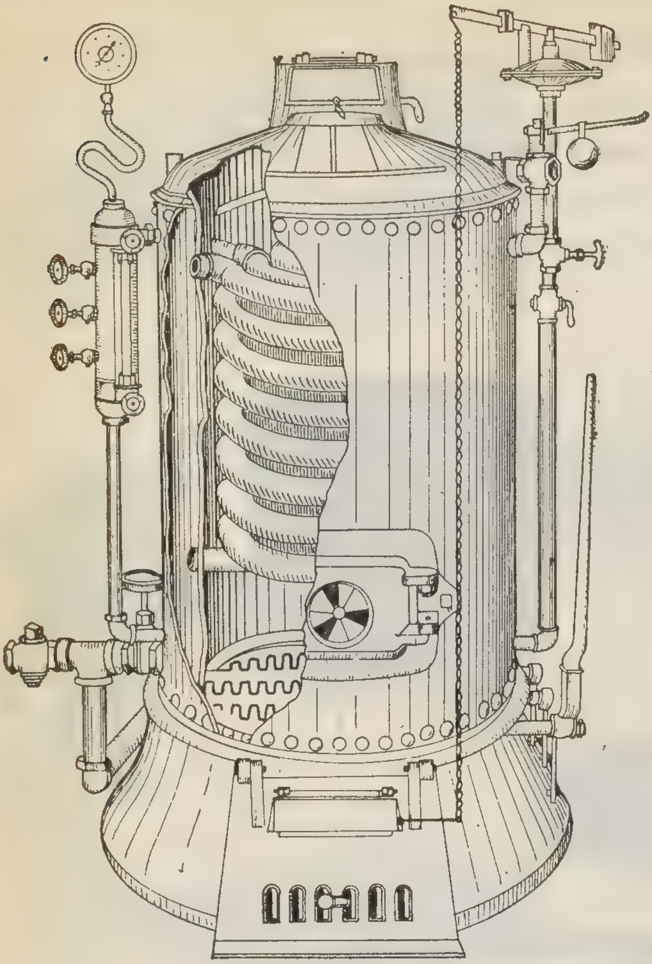
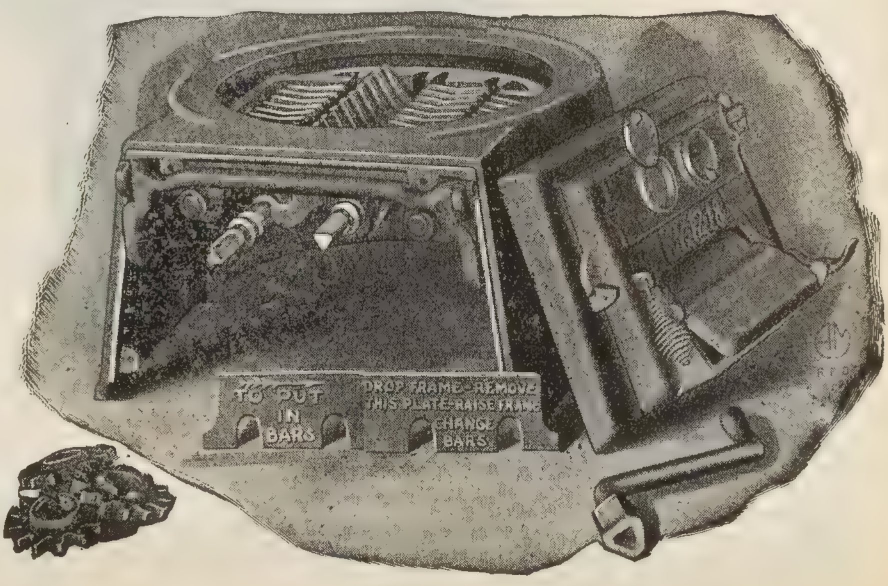


FIG.8,610.—Monitor coil boiler, ***In type,*** this is a combined shell and water tube boiler. The cut shows plainly the general construction, thus requiring no description. The form of heating surface is very efficient.



FIGS. 8,611 to 8,615. — International base, ash pit door, drop frame, grate gears and shaker.

Base.—This acts as a support for the fire pot and heating sections of the boiler. It should be so proportioned as to form a deep, commodious ash pit with a large ash door.

Usually a draught door is placed in the middle of the ash door, but in some designs, it is found on the side. This draught door should be balanced so accurately and work with such ease that it will open and close with the slightest variation of the steam pressure acting on the regulator.

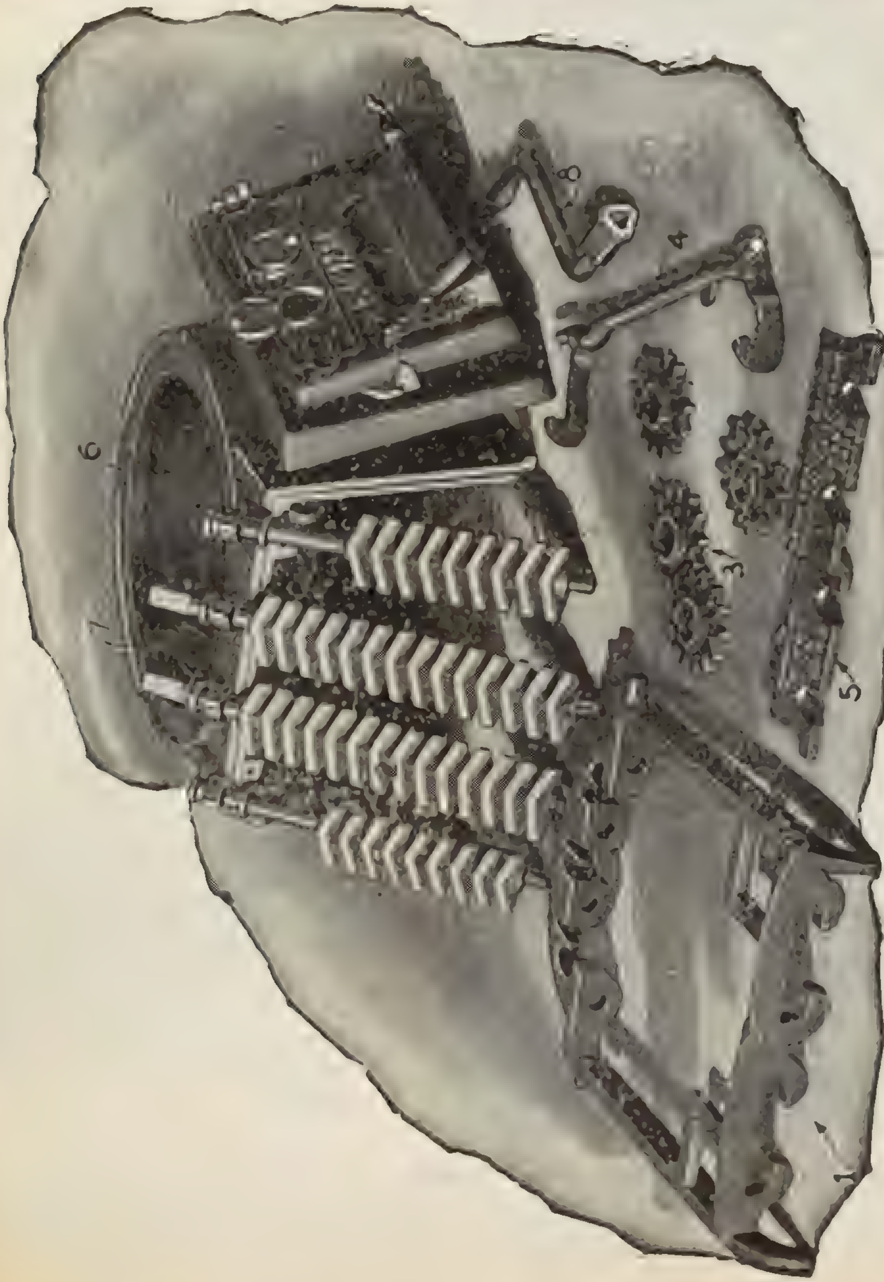


FIG. 8,616 to 8,629.—International base and grate dissembled. ***Directions for assembling the herringbone grate:*** Hang the drop frame 1, in the sockets 7; put the grate hanger 4, in the supports 9; now slip the grate bars 2, into the back holes 10, and front hooks 11. Slide the gears 3, onto the bars 2, and slip plate 5, into place.

The grate is located in the top of the base and is an important part of the apparatus. It should permit of both shaking and dumping, be easily accessible for repairs or renewal. Figs. 8,611 to 8,629 shows a typical base with ash and draught doors as constructed for a round, vertical boiler.

Fire Pot.—This is a most vital part of the boiler because especially, on account of the inadequate heating surface usually provided and the fact that the fire pot heating surface is more efficient than that further removed from the fire, the larger the fire pot heating surface and its coal capacity, together with proper combustion space and ample water passages, the more satisfactory will be the boiler's performance.

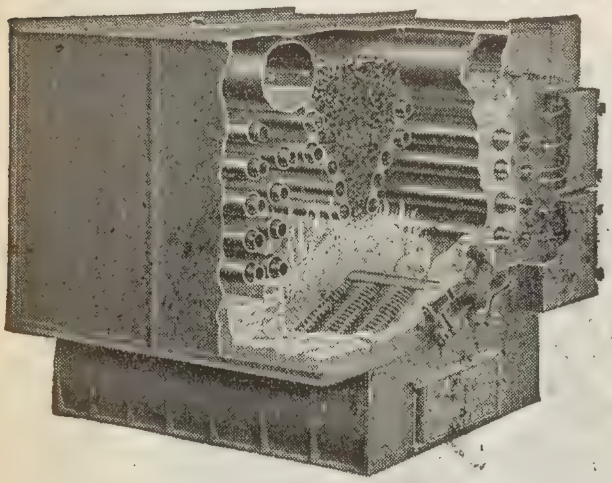


FIG. 8,630.—Spencer double tube magazine feed horizontal boiler showing general construction.

The fire pot in vertical boilers is usually made in a single casting, corrugations sometimes being provided to increase the heating surface.

In horizontal boilers it is built up from the sections, and also in some vertical boilers the fire pot is in several pieces. In the side openings are provided for the fuel and slice doors, the bottom of the slice door being on a level with the grate.

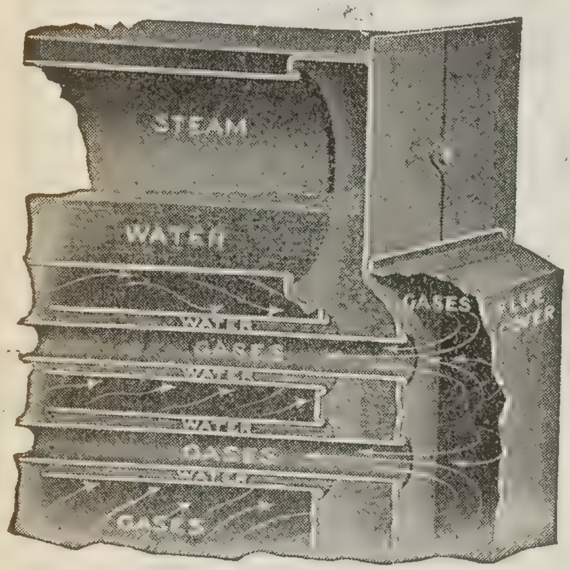


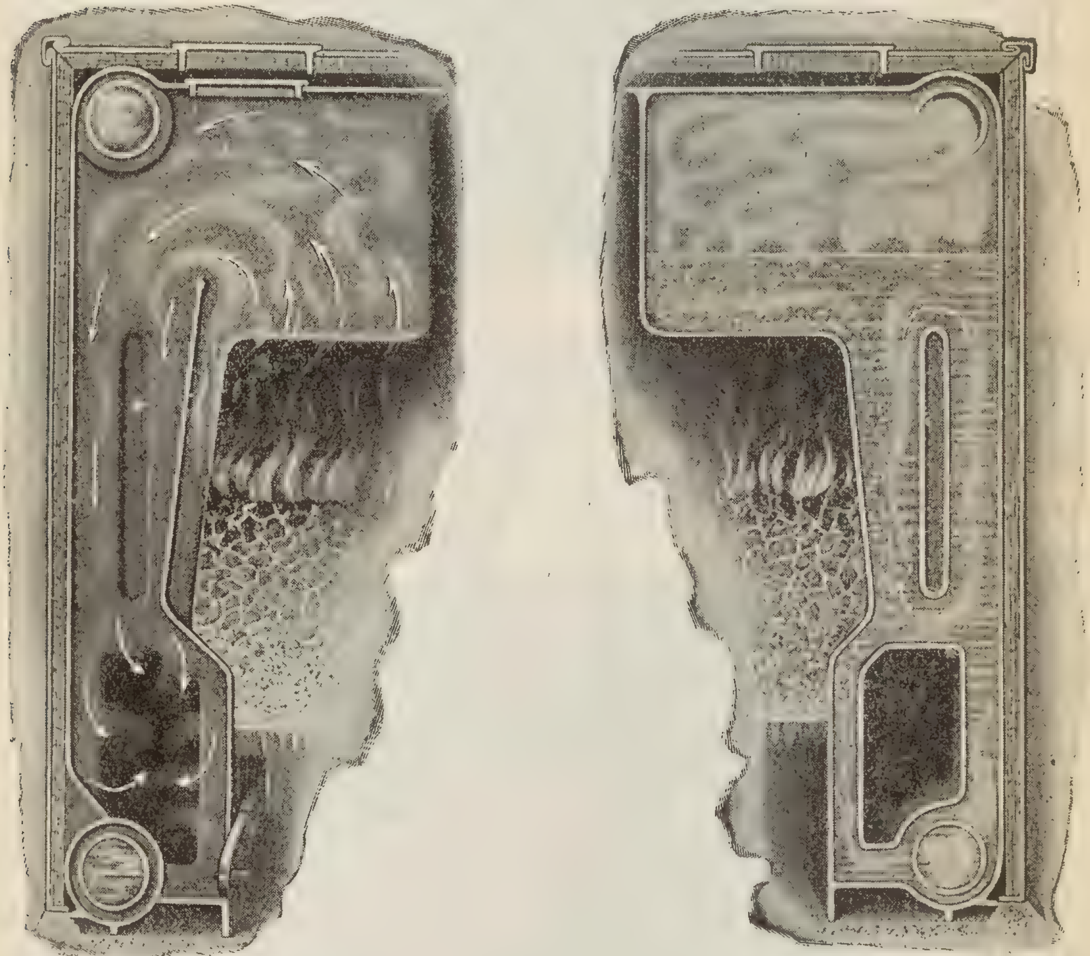
FIG. 8,631.—Gas and water travel in Spencer double tube boiler, showing water divided into annular streams between the outer and inner tubes with heating surface on both sides. This arrangement renders the heating surface very efficient.

Intermediate Sections.—Superposed on top of the fire pot of vertical boilers are one or more *intermediate* sections (sometimes more), consisting of hollow castings containing the water to be heated, and whose exterior forms heating surface.

Flue passages of proper area are provided through those castings, being staggered in adjacent sections so as to lead

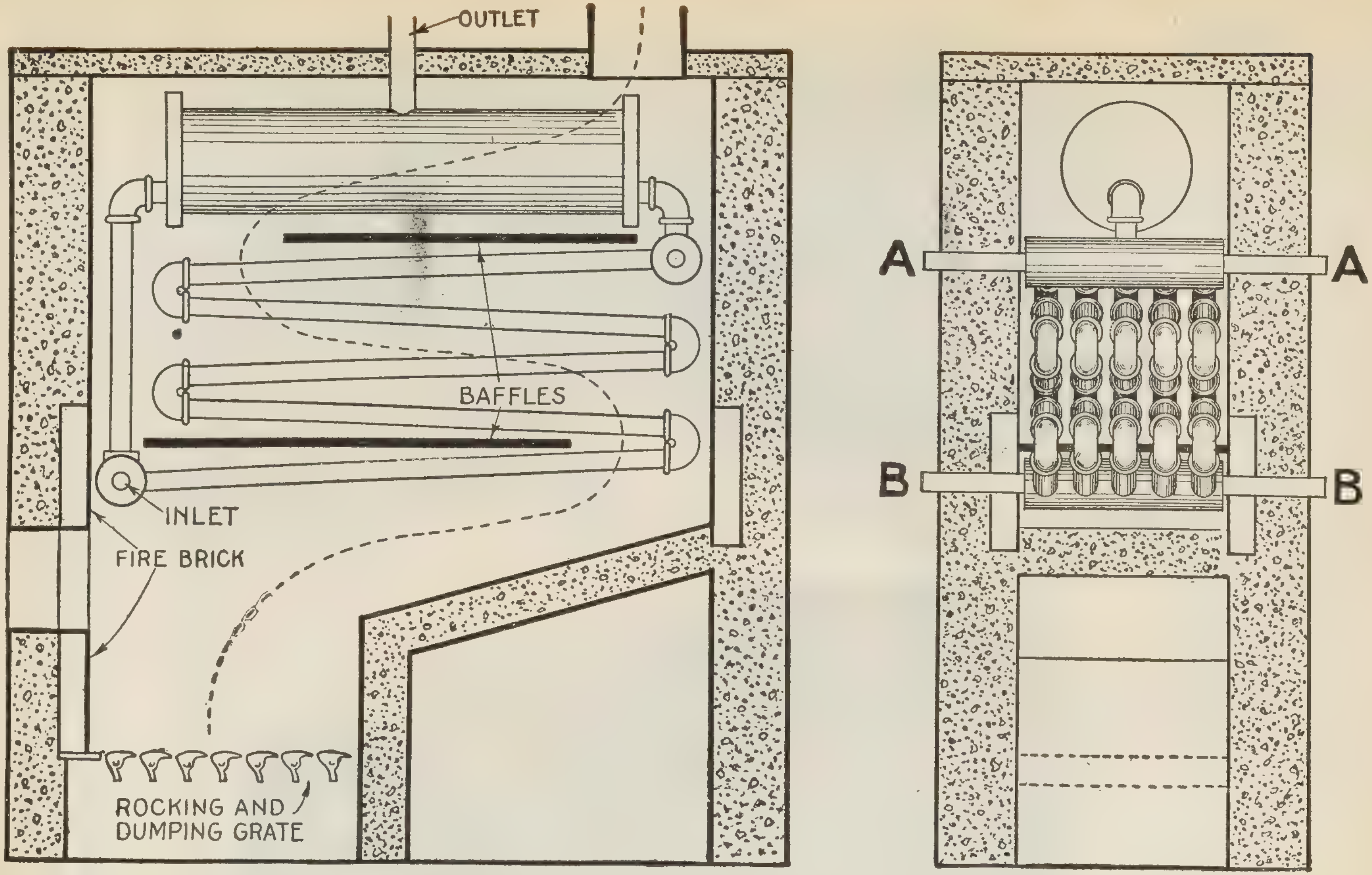
the gases in a roundabout way in traversing the heating surface, thus avoiding more or less short circuiting.

The practice of listing several sizes of boiler according to the number of intermediate sections piled up on the fire pot, all having the same size grate cannot be too strongly condemned; that is, by assuming different rates of combustion and adding a little extra heating surface, the rated radiation capacity is increased 50% or more.



FIGS. 8,632 and 8,633.—Half sections of Ideal horizontal heater showing flow of gases (fig. 8,632, and circulation (fig. 8,633).

As a matter of fact, for house heating boilers there is in general a particular rate of combustion (depending upon the intervals between firing, available draught, kind of coal, etc.), that will give the best all round satisfaction.



FIGS. 8,634 and 8,635.—Home made horizontal water tube boiler, designed by the author. Size of boiler grate, 2 square feet; heating surface, 50 square feet. It is made of ordinary pipe and pipe fittings. ***Material required:*** 125 feet of 1¼-inch pipe cut into 5-foot lengths making 25 5-foot lengths of pipe; 20 1¼-inch return bends; 2 branch tees, 5 1¼-inch run; 5½ feet of 6-inch pipe for drum; 2 6-inch by 2-inch reducing couplings for drum heads. A few extra feet of pipe for outlets, supports, down flow pipe, etc. Procure a grate, preferably of the shaking and dumping size and brick in as shown. The brick setting should be so constructed that by removing the top and unscrewing return connections AA and BB, the entire boiler can be lifted out in case of repairs.

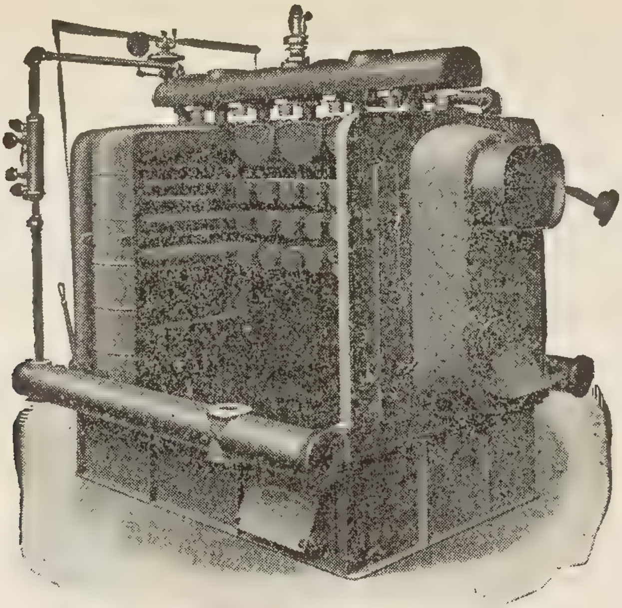


FIG. 8,636.—Gurney down draught boiler. ***Features:*** Separate half sections connected to top and side drums, cast iron sections in place of the usual one-piece castings, effective heating surface, accessibility for cleaning, steady water line, smoke consuming.

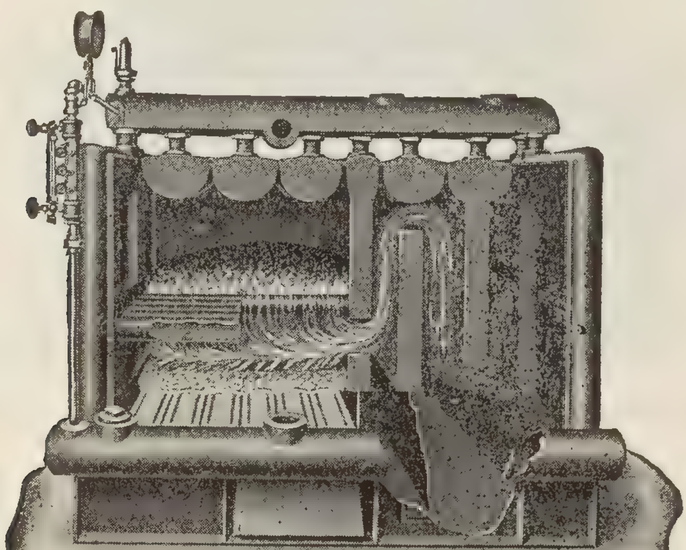


FIG. 8,637.—Gurney sectional boiler showing heating surface, long fire travel and horizontal arrangement of water tubes. Cut also shows method of dividing each section into half sections—a construction which insures freedom from breakage through sudden expansion or

If this rate of combustion be say 4 pounds per square foot of grate per hour and the capacity of fire pot be proportioned for 8 hour intervals between firings, evidently a different rate of combustion would be required for increased radiation capacity, or else a larger grate.

Increased capacity with the same size grate, means, not only a higher rate of combustion, but in order not to decrease the 8-hour interval between firings, a larger quantity of coal must be put on at each firing and this means a deeper fire pot to hold the excess coal, and a higher available draught in order 1, to maintain the increased rate of combustion, and 2, to force the air through the greater depth of fuel.

In the selection of a heater these items should be considered, also that whereas cast iron heaters are more durable than wrought iron heaters, wrought iron is a better conductor of heat than cast iron, thus for equal efficiency more heating surface should be provided for cast iron than for wrought iron.

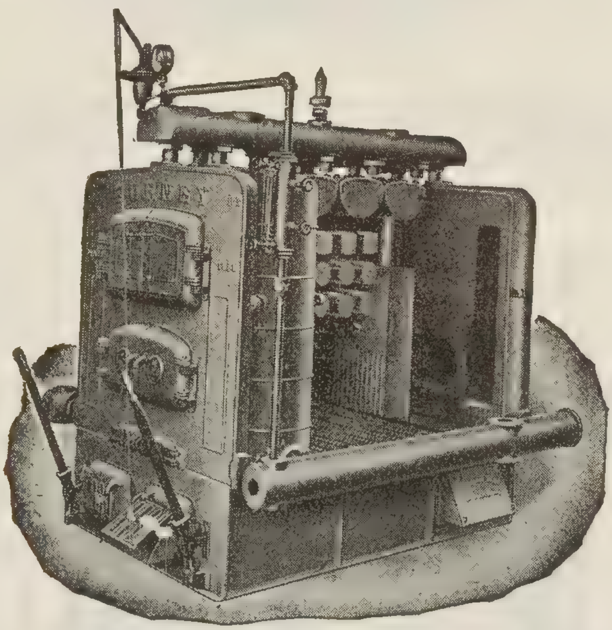


FIG. 8,638.—Gurney sectional boiler with bridge wall section and combustion chamber.

In the case of a vertical cast iron boiler, the author would recommend a high boiler consisting of several intermediate sections in preference to a low boiler without these sections, because the ratio of heating surface to grate area is increased.

In support of this advice it is only necessary to quote the results obtained from tests (as given in one manufacturer's catalogue), several cast iron boilers all having the same size grate, but with different number of sections:

Steam Heating Boiler Tests

Number of boiler	Fuel anthracite pounds per square foot of grate	Area of grate square feet	Number of sections including dome	Steam produced per pound of coal	8 hour rating square feet
0	4.39	1.23	*1*	*7.5*	200
1	5.12	1.23	2	8.	250
1½	5.28	1.23	3	8.5	275
2	5.44	1.23	*4*	*9.*	300

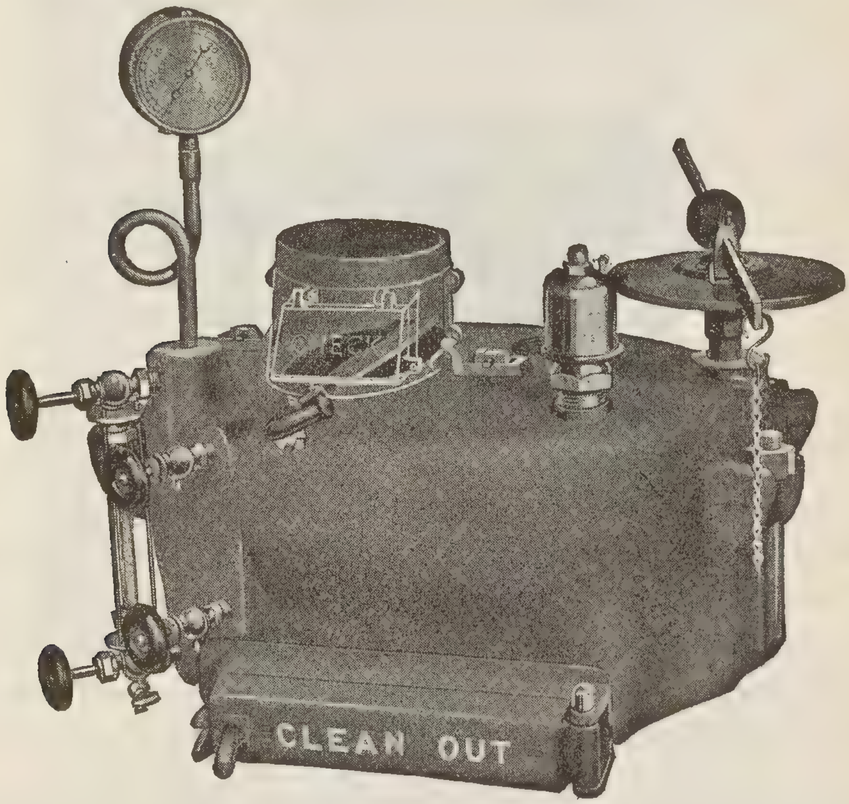


FIG. 8,639.—International steam dome showing water gauge, gauge cocks, steam gauge, damper, safety valve, automatic diaphragm regulator, and clean out door.

Since the number of sections as listed includes the top or dome, boiler O, had no intermediate sections. ***It will be noted*** that the evaporation in this boiler was only 7.5 pounds per pound of coal, and that even with the rate of combustion increased with the addition of intermediate sections, the evaporation increased from 7.5 to 9 pounds. It is simply a question

of whether the purchaser prefers a ***cheap** boiler and **big** coal bill, or an **expensive** boiler and **small** coal bill*—that is for him to decide.

The ratio of heating surface to grate, according to Kent is given for low, medium and high boilers, as 15, 20 and 25 to 1, where the rate of combustion is respectively 4 and 5 lbs. of coal per sq. ft. of grate per hour.

The author believes that in no case should there be less than 25 sq. ft. of heating surface per sq. ft. of grate, in order:

1. To obtain high efficiency under normal operation.

2. To permit forcing in extreme cold weather without material loss of efficiency.

3. To obtain quicker response especially in starting the fire.

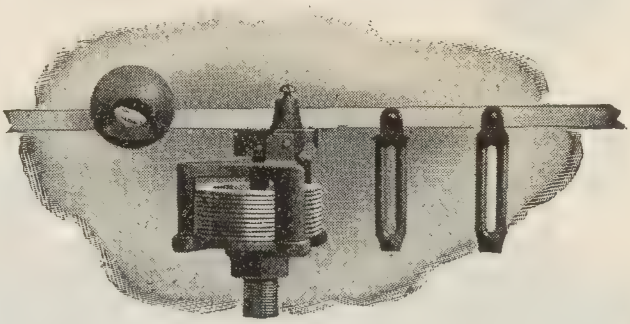


FIG. 8,640.—Ideal syphon steam regulator.

Steam Dome.—This section is placed on top of the intermediate sections in a vertical boiler and acts as a cover with an outlet to smoke stack and forms an enclosed space for steam and water. In some designs the dome is really two sections cast in one piece that is two water spaces with a smoke space between.

The dome is usually made of larger diameter than the water section to increase the extent of the liberating surface and provide ample space for the steam so as to avoid priming.

Automatic Control.—In order that steam may be maintained at a constant pressure during the long intervals when the boiler is unattended, some method of automatic control of the

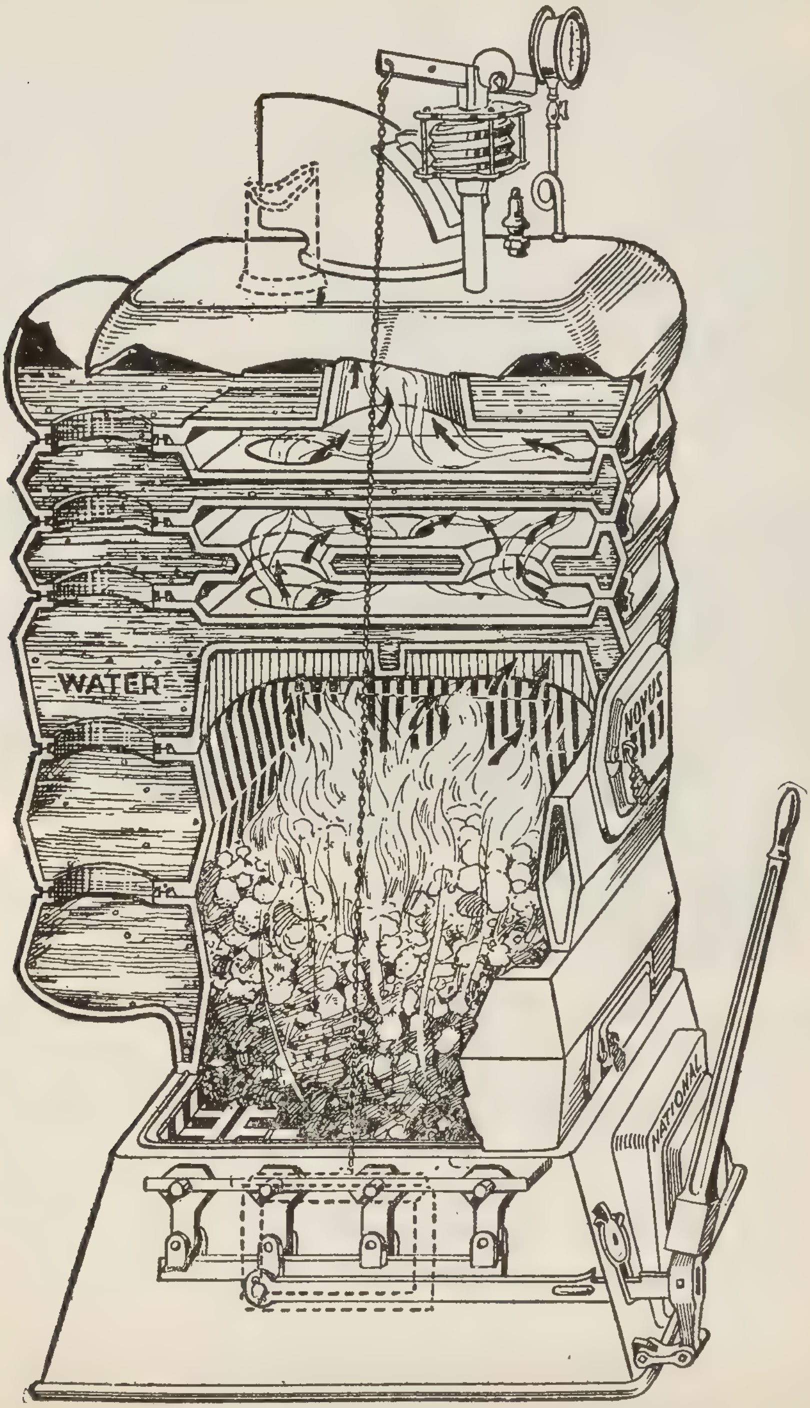


FIG. 8,641.—National boiler; sectional view showing interior construction and location of nipples.

fire is essential. This is accomplished by means of a diaphragm regulator as shown in fig. 8,639.

In construction, two oval shaped castings form the case of the regulator, the upper one inverted and bolted to the lower one with a rubber diaphragm between.

The lower casting is connected to the boiler (preferably below the water line), so that the steam pressure acts on the lower side of the diaphragm.

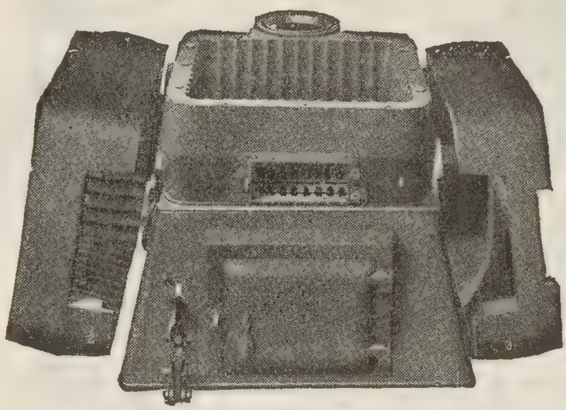
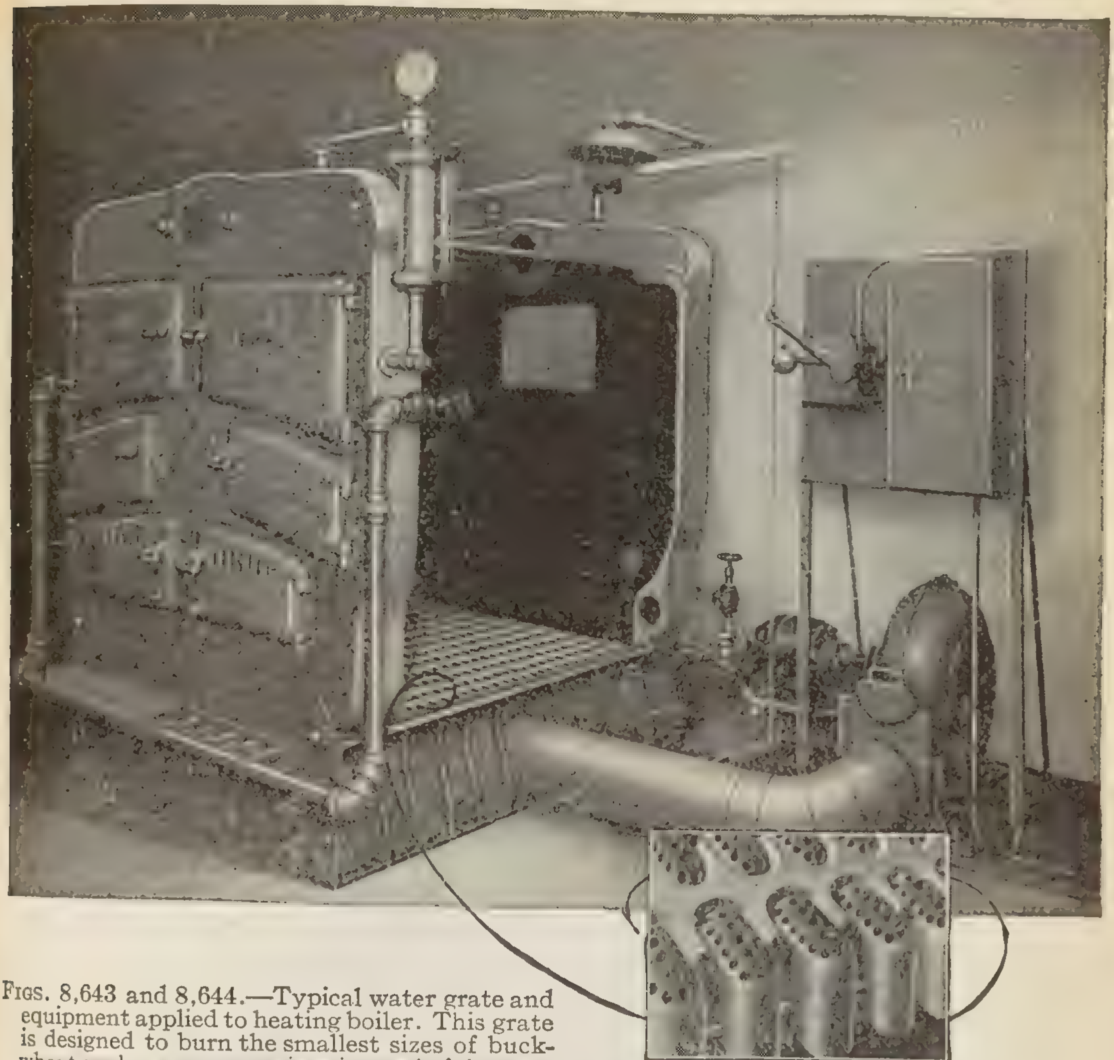


FIG. 8,642.—Three piece fire pot of National boiler showing corrugated walls to augment heatingsurface.

The upper casting has an opening in the center through which is placed a small plunger, whose lower end rests on the diaphragm and the upper end is bolted and pivoted to a long lever as shown.

One end of the lever is connected by chains to the draught door and the other to a damper in the stack.

An adjustable weight is adjusted so that when there is no steam in the boiler it will push down the diaphragm and elevate the end connected to the draught door, which opens this door wide.



FIGS. 8,643 and 8,644.—Typical water grate and equipment applied to heating boiler. This grate is designed to burn the smallest sizes of buckwheat coal or even screenings instead of the more expensive large sizes of coal. This is a forced draught system in which air under pressure is delivered to an air tight ash pit by a blower driven by an electric motor under automatic control. A large number of air distributers are provided as shown in detail in fig. 8,644. A multiplicity of holes are drilled through these distributers to the domed top so that the air sweeps across the grate at an angle—thoroughly aerating the entire body of the coal. This insures an equal distribution of air over every square inch of the grate surface. The distributer is of the full depth of the grate bar, thus preheating the air. Steam is maintained at a constant pressure by a diaphragm regulator which controls an air damper. ***Thus,*** if the regulator be set for say 3 lbs. steam pressure, when the steam gauge shows this pressure the diaphragm moves, closing the air damper and stopping the motor; when the pressure begins to fall, the diaphragm moves in the opposite direction opening the damper and starting the motor.

NOTE.—***Method of adjusting water regulators.*** Before starting fire and heating water, remove both weights, which leaves the lever nearly horizontal. Connect chains and cable as shown, using cable over the pulleys so that when both dampers are closed and the lever horizontal the chain and cable will be taut. Place one weight on the rear of the lever and start fire. Adjust this weight at such point that the regulator will tilt the lever and check the fire when water temperature has reached the degree desired to be maintained. The forward weight is not always necessary and is generally used to balance dampers when rear damper is specially heavy.

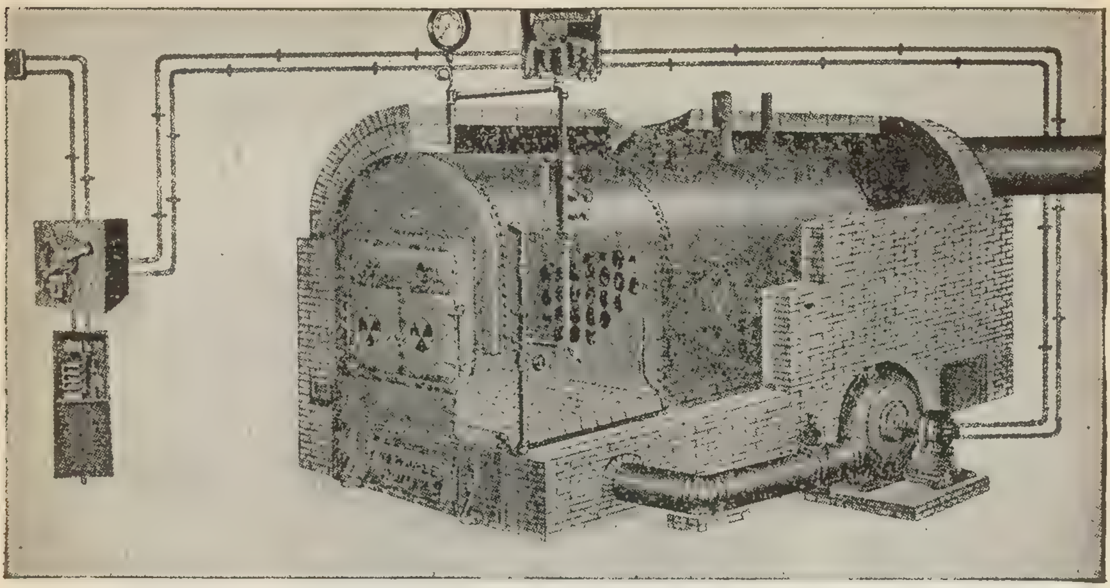


FIG. 8,645.—Premier forced draft water grate bars system; sectional view of boiler equipped with Premier water grate bars and blower connection showing method of forcing air into ash pit chamber beneath grate bars. Note brick wall used as grate bar rest, built inside of sealed chamber.

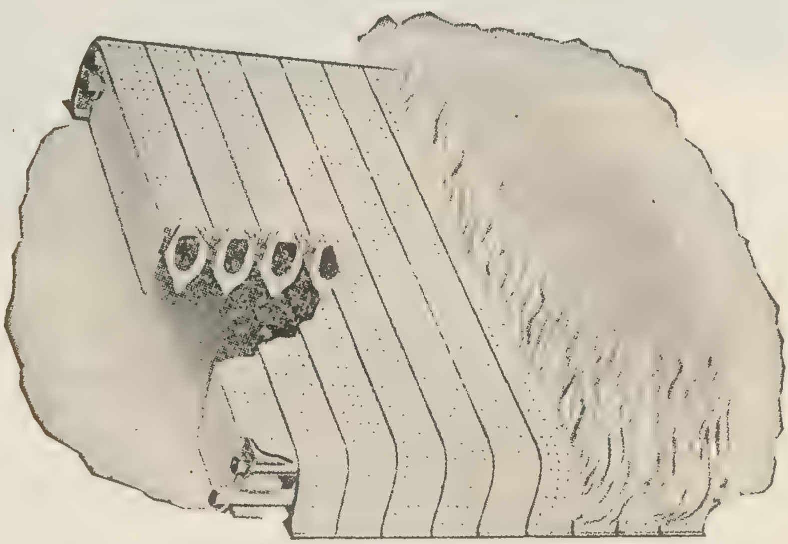


FIG. 8,646.—Detail of Premier water grate bars as assembled in boiler, showing water circulation through individual bars, thereby cooling bars and preventing burning, melting or warping. ***In operation,*** there is a constant circulation of water from the boiler into the grate bar water ways, the water flowing back into the boiler as it reaches a high degree of heat. This added feature gives the boiler increased heating surface. Note tie rods that keep grate bars firmly together.

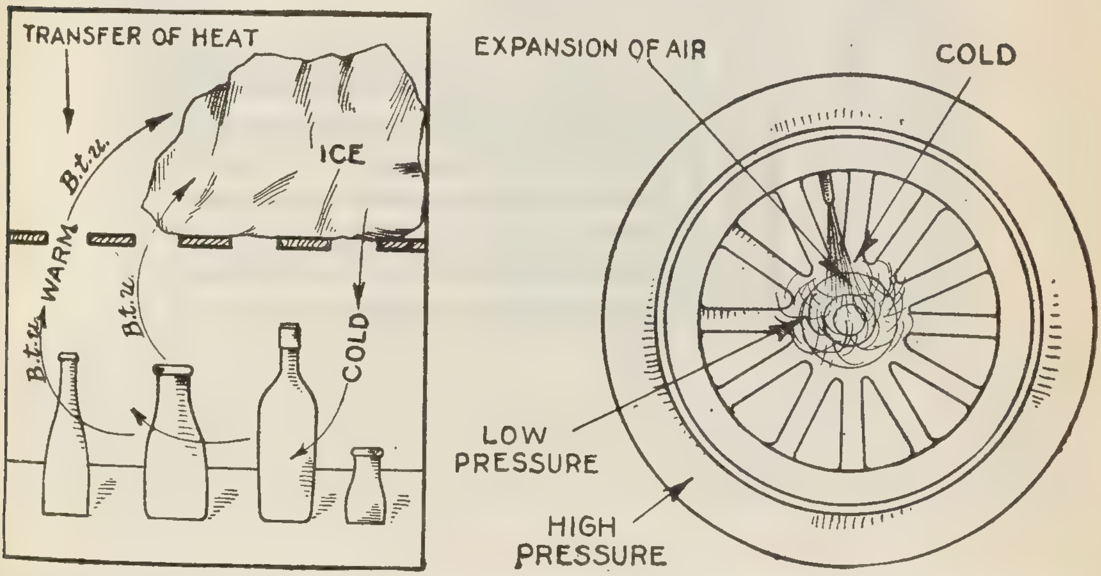
CHAPTER 126

Refrigeration

Refrigeration may be defined as the process of lowering the temperature of a body or of keeping its temperature below that of the atmosphere.

Low temperatures may be produced:

1. By transfer of heat from a warm to a cold body.



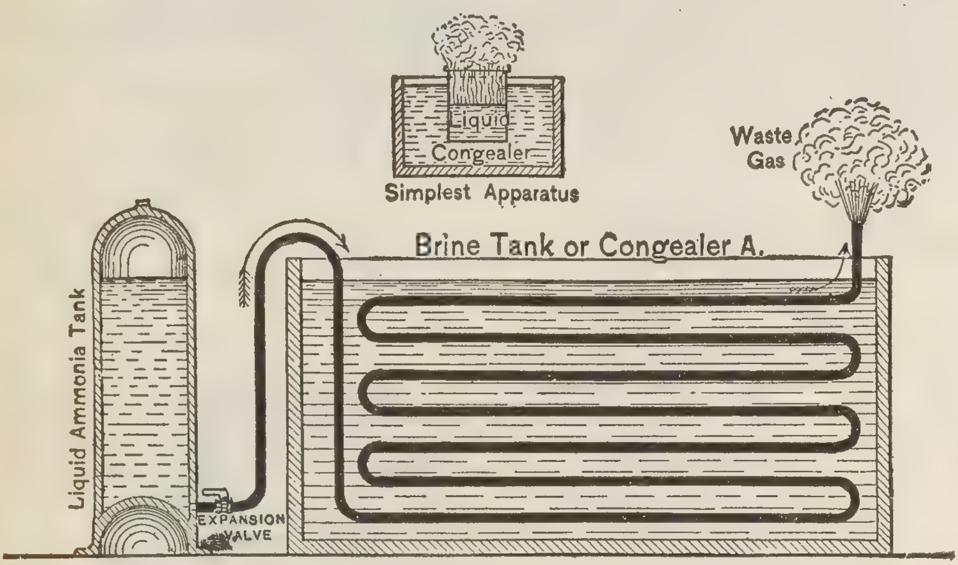
FIGS. 8,647 and 8,648.—Methods of refrigeration, fig. 8,647, by transfer of heat from a warm to a cold body; fig. 8,648, by expansion of a gas. Fig. 8,647 shows the familiar process which takes place inside an ice box, and fig. 8,648 what happens when the valve inside is suddenly removed from a tire.

2. By expansion of a gas.
3. By evaporation of liquids having low boiling points.

Classification of Systems.—The numerous systems of refrigeraration may be classified according to several points of view as:

1. With respect to the heat absorbing medium or cooling agent employed as:

1. Ammonia.
2. Carbonic acid.
3. Sulphur dioxide.
4. Pictet fluid.
5. Sulphuric ether.
6. Methylic ether.
7. Ethyl chloride.
8. Air.



FIGS. 8,649 and 8,650.—Refrigeration by evaporation of ammonia. The ammonia tank containing ammonia under pressure is connected to the evaporating coil by means of an expansion valve. The liquid through its evaporation takes up heat from the contents of the congealer. Such an arrangement as shown here would not be practical in actual practice as the gas is allowed to go to waste and in order to use it over again more apparatus than shown here has to be used.

2. With respect to the working of the heat absorbing medium or cooling agent as:

*a. **Compression*** {wet, dry}

*b. **Absorption***

3. With respect to the manner of applying the refrigeration as:

a. Direct expansion.
b. So called indirect expansion or brine circulating.
c. Semi-indirect expansion or brine congealing.
d. Cold air.
e. Pipe line.

The ammonia compression system and the ammonia absorption system are the most extensively used systems.

Ammonia Compression System.—In this system ammonia

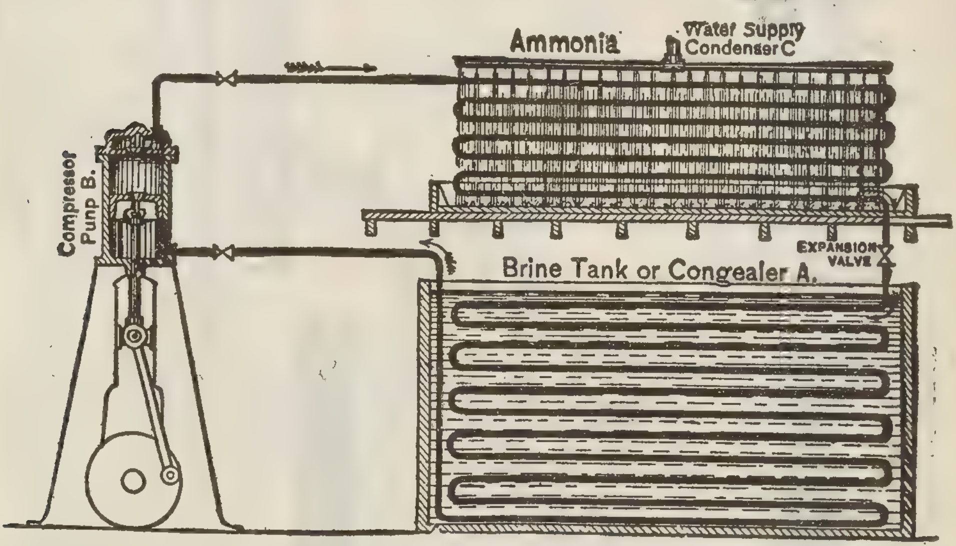


FIG. 8,651.—Diagram showing the essentials of a mechanical ***compression system*** with vertical compressor. The condenser shown is of the atmospheric type, and the brine circulating system is used, the brine being cooled by the expansion coils in a tank and then circulated through pipes in the refrigerating rooms.

vapor is compressed to about 150 lbs. pressure, and is then allowed to flow into a cooler or surface condenser, where the heat due to the work of compression is withdrawn by the circulating water and the vapor condensed to a liquid. It is then allowed to pass through an expansion cock and to expand in the piping thereby withdrawing heat from the "brine" with which the pipes are surrounded. This brine is then circulated by pumps through coils of piping and produces the refrigerating effect.

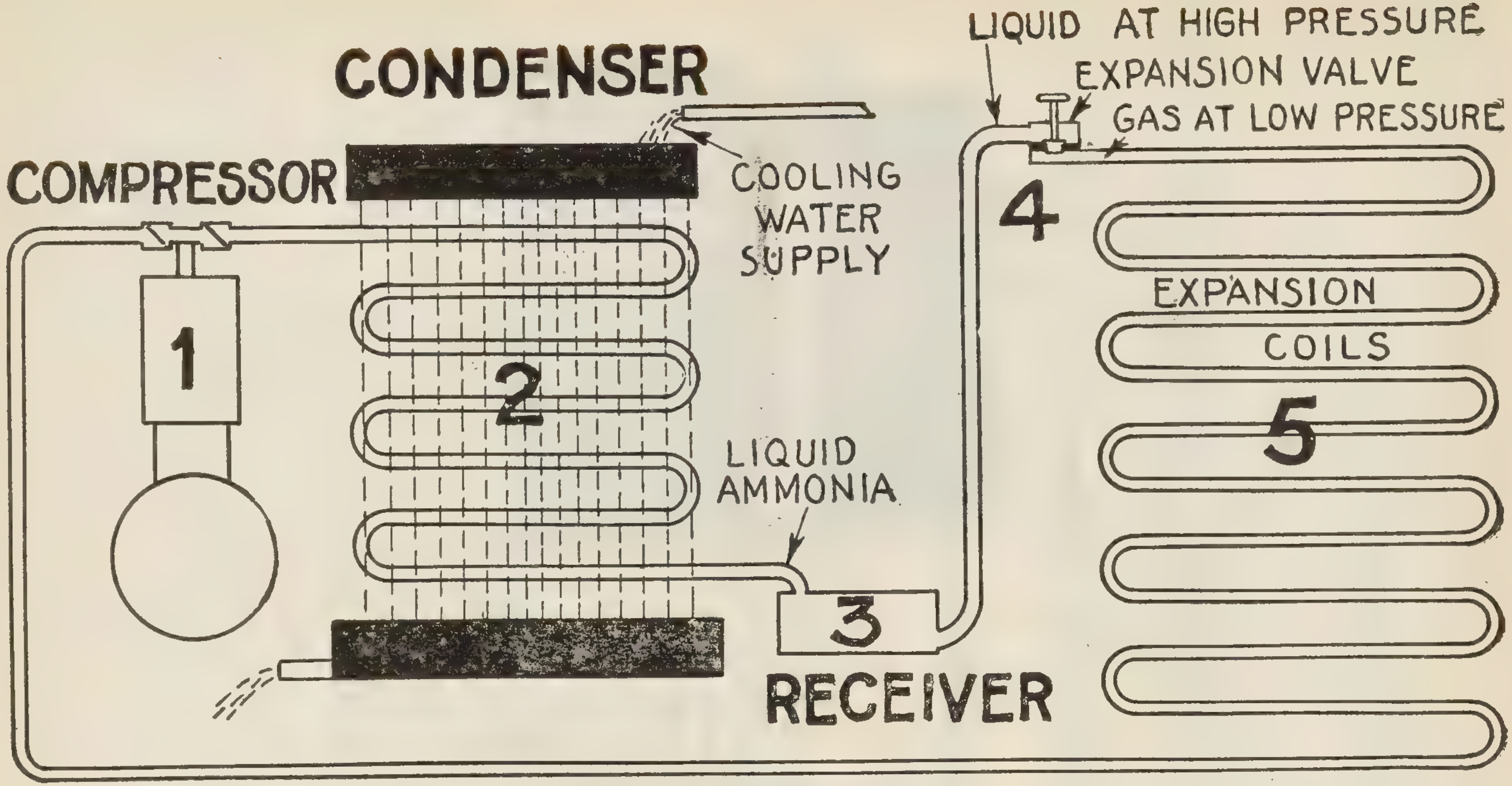


FIG. 8,652.—Elementary ***ammonia compression system***; *direct expansion*. ***The essential parts are***: 1, compressor; 2, condenser; 3, receiver; 4, expansion valve; 5, expansion coils. From the discharge valve of the compressor to the expansion valve is the *high pressure* portion of the system, and from the expansion valve to the suction valve of the compressor, the low pressure portion. ***Cycle of operation:*** 1, compressor compresses ammonia gas to about 150-170 lbs.; 2, gas is cooled in condenser and condenses, passing into receiver in a liquid state; 3, pressure is reduced by throttling in passing through expansion valve, causing vaporization of the liquid ammonia; 4, the latent heat of vaporization is absorbed from surrounding substances in passing through the expansion coils producing the refrigeration effect; 5, ammonia gas returns to compressor, thus completing the cycle.

The expanded ammonia gas is then drawn into the compressor under a suction of from 5 to 20 lbs., thus completing the cycle of operation. The brine consists of a solution of salt in water.

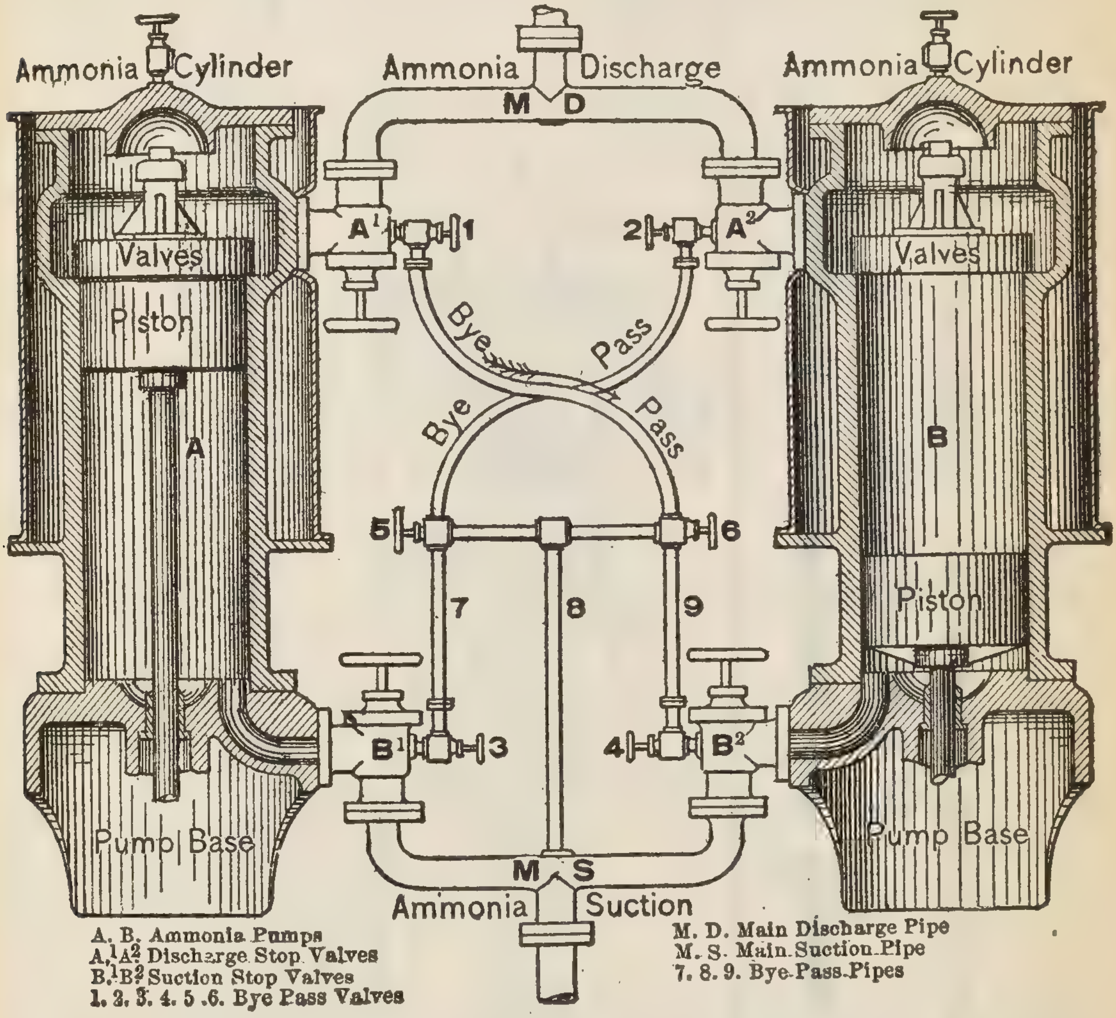
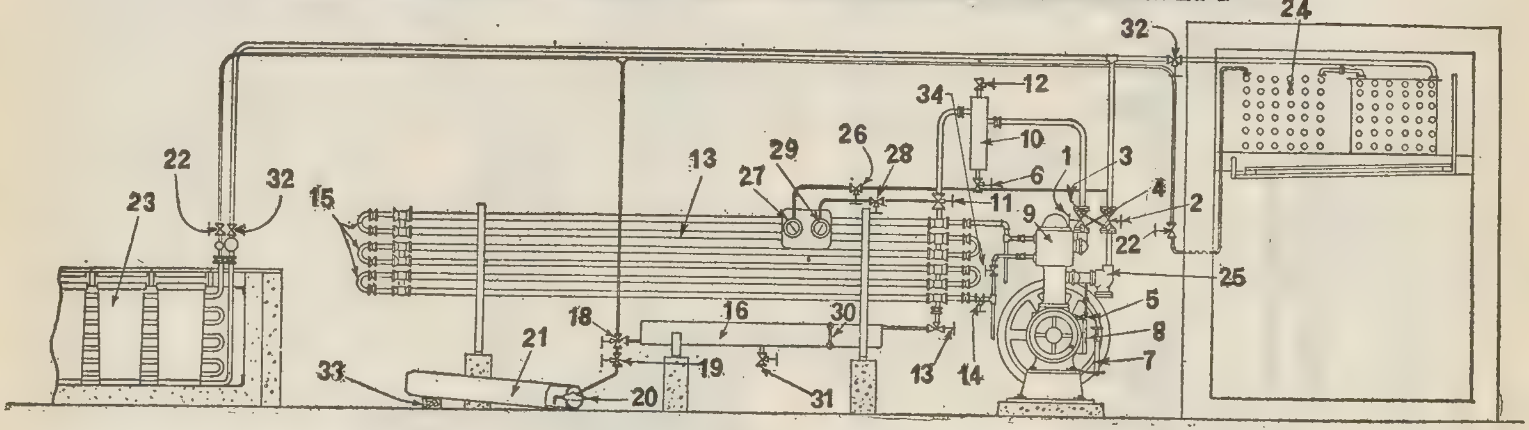


FIG. 8,653.—Single acting Frick compressors, showing by pass system. A. B. compressor cylinders; A^1, A^2, discharge stop valves; B^1, B^2, suction stop valves; 1, 2, 3, 4, 5, 6, by pass valves; M, D, main discharge pipes; M, S, main suction pipes; 7, 8, 9, by pass pipes. ***To exhaust*** gas from compressor B (large machines): All valves closed. Open main discharge stop valve A^1 and by pass valves 2 and 3. Run machine slowly until compressor cylinder is exhausted, then close by pass valve 3 and cylinder head may be removed. After replacing cylinder head the air may be expelled by closing main stop valve A^1 and discharging through purging valve on head of cylinder A. To exhaust gas from compressor A, proceed in same manner, using opposite set of valves. ***To exhaust*** ammonia condenser ***and store*** in evaporating coils or low pressure side: Open main discharge stop valve A^1, by pass valves 1 and 4, thus connecting to suction of cylinder B, and expelling gas by opening by pass valves 2, 5 and 7 into main suction pipe. Run machine slowly. By using opposite set of valves the other cylinder may be used, as one is used to exhaust the gas from the discharge through by pass, while the other expels it through the other portion of by pass into the suction pipe and low pressure side. When the machine is running on regular duty the by pass valves must be kept closed.

INSTRUCTIONS FOR OPERATING
FISHER
Ice Making and Refrigerating Machinery



TO START COMPRESSOR.

Open valves Nos. 14 and 34 and make sure that water is running. Open Valve No. 1 wide, then start machine. Now open valve No. 2 slowly. When pressure indicated by low pressure guage No. 27 registers 10 pounds or below, open liquid stop valve No. 18. It is understood, of course, that the expansion valves have been previously adjusted, for after their initial adjustment is made, they should never be bothered except when charging plant or in making repairs.

Adjust these valves (Nos. 22) so that after machine has been operated for some time, no frost will show outside of tank or cooler nearest machine or at the most never closer to compressor than the scale trap.

TO STOP COMPRESSOR.

Close liquid stop valve No. 18 and continue operating machine until low pressure guage No. 27 shows about 5 pounds; now close suction stop valve No. 2 and shut off power. Close discharge stop valve No. 1 and shut off water supply by closing valves No. 14 and 34.

FIG. 8,654.—Fisher ammonia compression plant illustrating operation.

Liverpool salt solution weighing 73 lbs. per cu. ft. (sp. g. = 1.17) will not congeal at 0° F.

American salt brines of the same proportions congeal at 20° F. Ammonia required = .3 lb. per foot of piping. Leakage and waste amount to about 2 lb. per year per daily ice capacity of one ton. The brine should be about 6° colder than the space it cools.

There are two methods of compressing:

1. Dry.
2. Wet.

Compression in a cylinder cooled by a water jacket is called dry compression.

In the wet method the cylinder is not jacketed, but a certain amount of liquid anhydrous ammonia is allowed to enter the cylinder with each stroke, the cylinder walls being cooled by its evaporation.

The wet system is harder on packing, as there are few soft packings that will stand the freezing action of the liquid anhydrous ammonia without becoming hard and causing leaky stuffing boxes.

Ammonia Absorption System.—In this system the compressor is replaced by a vessel called the absorber, where the expanded vapor takes advantage of the property of water or a weak ammoniacal liquor (called the "weak liquor") to dissolve ammonia gas. (At 50° Fahr. water absorbs 727 times it volume of ammonia gas.)

The principle of the absorption system may be stated as *the alternate repulsion and absorption of ammonia gas by the alternate heating and cooling of ammonia water*.

In the elementary absorption plant the essential parts are:

1. Generator
2. Condenser
3. Expansion coils
4. Absorber
5. Pump
6. Exchanger or intercooler

these being shown in the diagram, fig. 8,656.

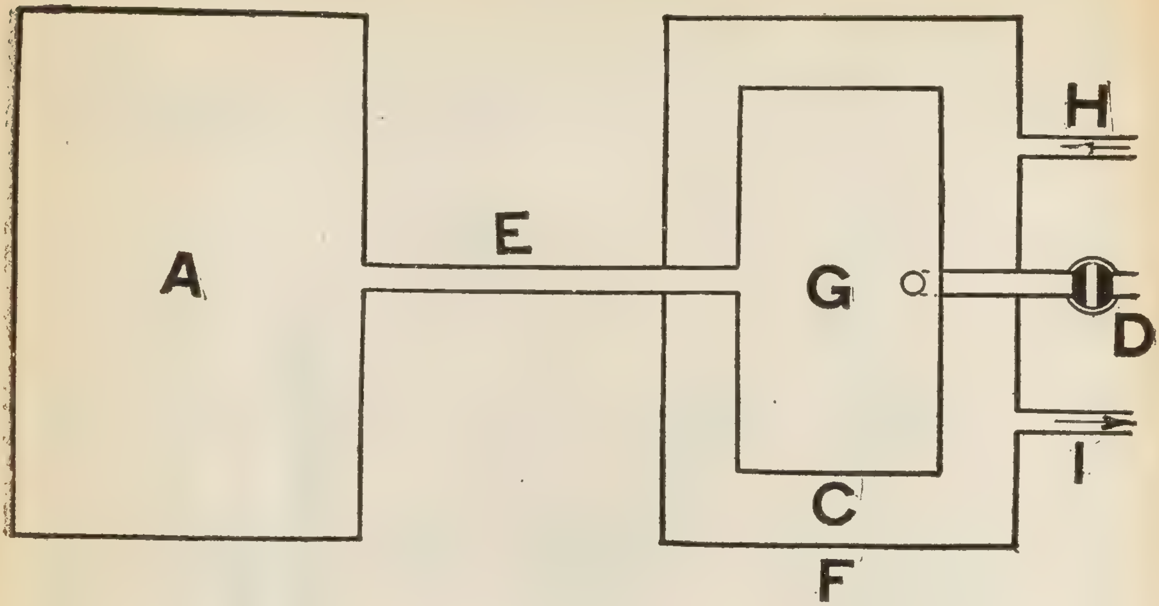


FIG. 8,655.—Diagram illustrating general principle of the ammonia absorption system. In the figure two vessels, A and G, of proper strength to resist internal pressures of 10 to 15 atmospheres (140 to 220 lbs. per sq. in.), are connected at their tops by a pipe E. The smaller vessel G, is enclosed within a jacket F, through which and around G, cold water is circulated, entering at H, and leaving at I. The larger vessel A, is partially filled with a strong solution of aqua ammonia and heat is applied as by a fire underneath the vessel A. As the ammonia warms, ammonia gas is driven off and fills G, through the pipe E, air being allowed to escape from the system through a suitable opening in the bottom of G. When ammonia gas begins to issue strongly from this opening, the escape is closed by a cock D, provided for the purpose. Since the volume of gas in solution in the liquor in A, is many times that of the water itself, the continued application of heat drives off such quantities of the gas as to create a constantly increasing pressure in the system. Just as in the case of water, ammonia has for every pressure a corresponding temperature of boiling and of liquefaction, at which temperature ammonia gas will liquefy if heat be abstracted from it, and ammonia liquid will gasify if heat be added to it. If the cooling water have a temperature of 60° F., and maintain the vessel G, and its contents at a temperature of, say, 65° F., it is evident that when the pressure of the gas within G, reaches about 103.33 lbs. per sq. in. by gauge (118.03 lbs. absolute), the further expulsion of gas from the liquor in A, causes a corresponding liquefaction of ammonia in G, and by continuation of the process an accumulation of liquid ammonia results in G, until all the gas has been driven off from the water in A, the pressure remaining constant during the process and the latent heat of a liquefaction being carried away by the cooling water flowing out at I. When the distillation of ammonia into G, is completed, the process may be reversed by cooling A. This enables the water in A, to absorb and dissolve the gas in contact with it, creating an immediate flow of gas from G, and causing a reduction of pressure in the system. This decrease of pressure lowers the boiling temperature of the liquid ammonia in G, and consequently it at once starts to gasify. Now as, in liquefying, the ammonia yielded up its latent heat to the cooling water in C, so, in gasifying, heat must be abstracted by the ammonia from its surroundings. Hence, if the flow through C, be stopped, the water remaining around G, will be cooled and utimately frozen. If then, a brine whose freezing temperature is low, be substituted for the water in C, it may be piped away for cooling storage space or may freeze cans of water immersed within it for ice making purposes.

The cooling agent (ammonia water mixed in proportions of about one and two respectively), is placed in the *generator*, where it is heated by steam coils containing low pressure steam, usually the exhaust from the circulating pump, and due to this heat,

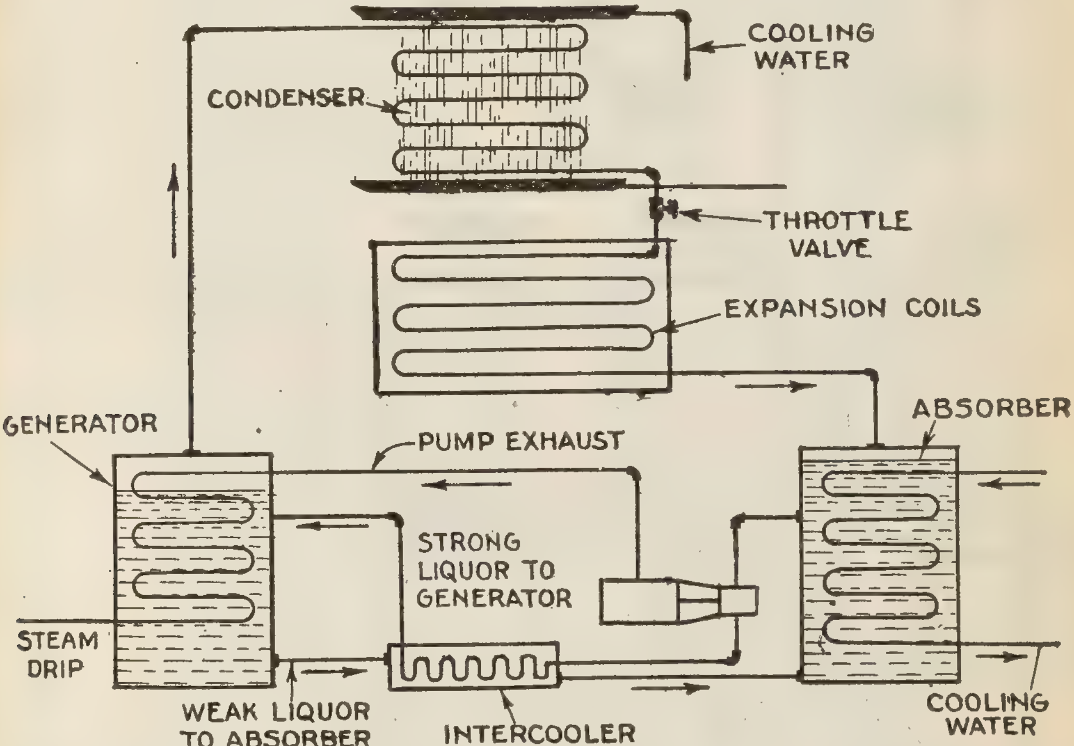


FIG. 8,656.—Elementary ***ammonia absorption system***; *direct expansion cooling.* The essential parts are: 1, generator; 2, condenser; 3, expansion coils; 4, absorber; 5, pumps 6, exchanger. As compared with the compression system the absorber takes the place of the compressor. ***Cycle of operation:*** 1, the strong liquor vaporizes in generator; 2, ammonia gas produced in generator passes to condenser and condenses; 3, liquid ammonia from condenser passes through expansion valve and vaporizes in the expansion coils which produce; the cold or refrigerating effect; 4, ammonia gas from expansion coils is absorbed by the weak liquor in the absorber, producing strong liquor; 5, the strong liquor is pumped from the absorber to generator via the exchanger, where the hot weak liquor passing from generator to absorber gives up some of its heat to the strong liquor, thus completing the cycle.

NOTE.—If a solution of NH_3 and water (ammonia liquor) be placed in a boiler, termed a "generator," and sufficient heat supplied by a steam coil be applied, both superheated NH_3 gas and steam will be driven off or generated. The total pressure existing in the generator is made up of the partial vapor pressures of NH_3 and H_2O. The vapors on leaving the generator are first passed through a cooler (termed a rectifier or dehydrator) which is connected with the cooling water supply. A temperature is maintained in the rectifier which is sufficiently low to condense out practically all of the water vapor, approximately 90 per cent., but not the ammonia. The condensed water reabsorbs some of the NH_3 gas and is dripped back into the generator as rich liquor. This leaves practically dry NH_3 gas to be passed to an NH_3 condenser to be liquefied. The liquid NH_3 is then expanded in evaporating coils and refrigeration produced as in the compression system. The expanded NH_3 gas leaving the evaporating coils passes to the "absorber" where it is reabsorbed by the weak liquor drawn from the bottom of the generator. The rich liquor produced by the absorption is then pumped back to the analyzer and generator to repeat the cycle. The analyzer, located on top of the generator, consists of a series of trays over which the rich liquor flows on its way to the generator. The

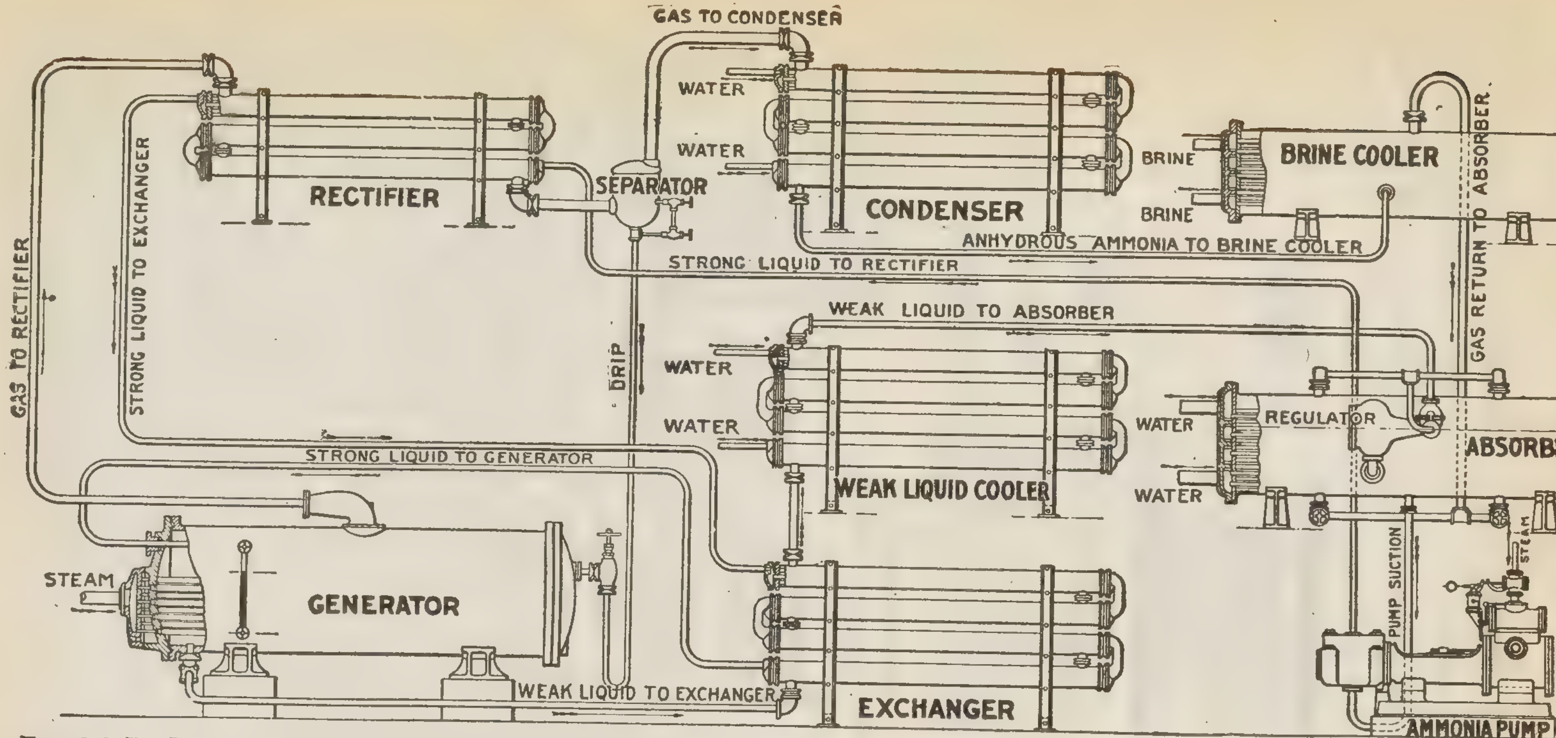


FIG. 8,657.—Vogt absorption refrigerating machine, showing *pipe connection and directions in which the liquids and gases travel throughout the entire system. The machine here shown is of tabular construction.* ***In operation,*** the ammonia is evaporated out of the rich liquor in the generator and analyzer, and passed on into the rectifier; from the rectifier the gas passes to the condenser. The anhydrous ammonia passes from the condenser to the liquid receiver which is simply a reservoir. The receiver is connected to the expansion valve by a pipe of comparatively small size. The expansion valve is regulated so as to allow enough ammonia to enter the cooler to keep the latter at the required temperature. From the cooler the ammonia vapor is led to the absorber into which the poor liquor is sprayed, coming from the exchanger and passing through the weak liquor cooler. The rich liquor is taken from the absorber by the pump and discharged through the exchanger into the analyzer from whence it flows into the generator. The poor liquor is forced by pressure from the generator through the exchanger. In the exchanger the outgoing poor liquor gives up part of its heat to the incoming strong liquor.

ammonia gas under pressure is liberated from the water and passes on to the condenser where it is cooled and liquified.

The liquid ammonia then passes into the expansion coils, where it vaporizes and absorbs heat from the surrounding substances thus providing the refrigerating effect, and the warm gas from these flows into an absorber, a tank containing the weak ammonia water (called the "weak liquor"), that is, that which has previously given up its gas in the generator. In the absorber are coils containing cold water, and the ammonia vapor coming from the expansion coils is absorbed by this

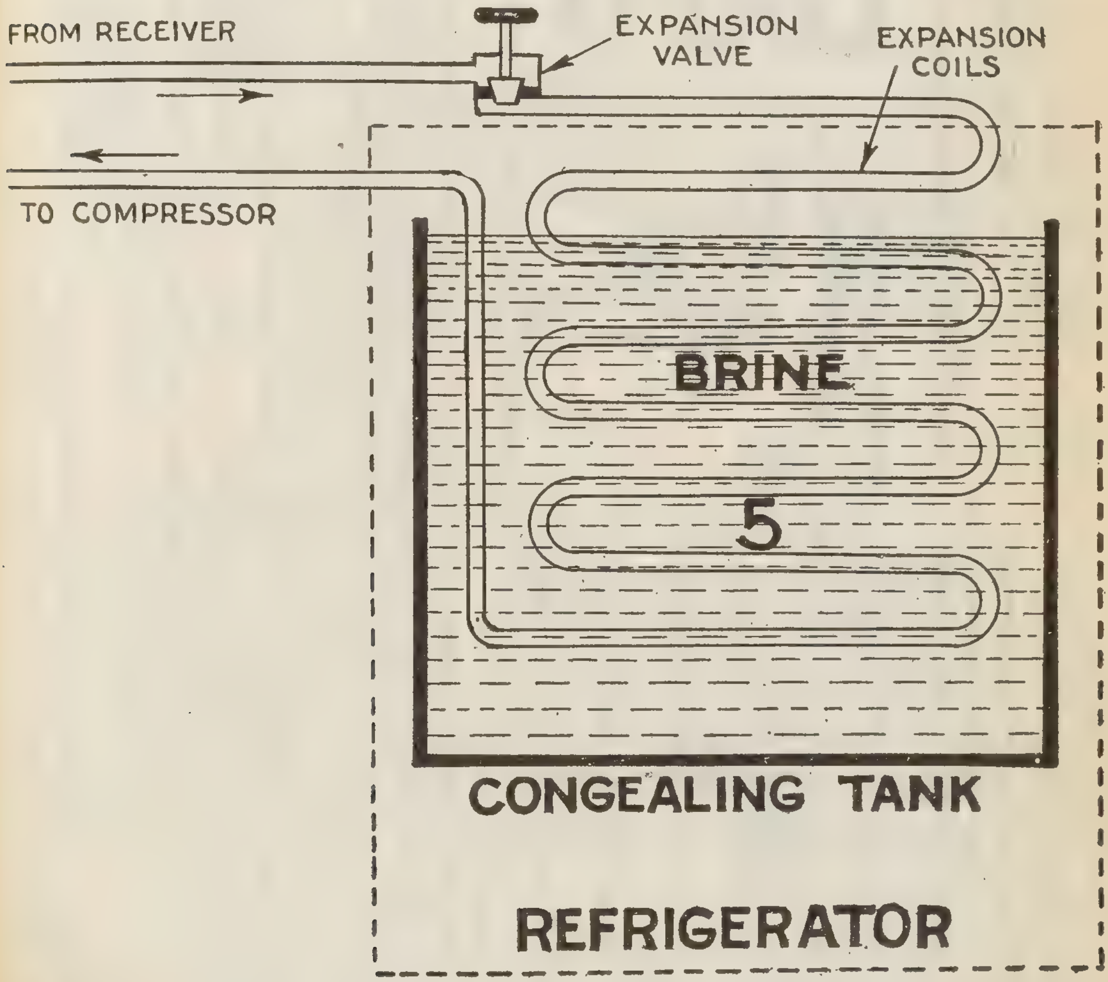


FIG. 8,658.—Elementary ***ammonia compression system;*** *semi-indirect or congealing tank transmission.* As shown the direct expansion piping is located in the refrigerator but is submerged in a tank filled with brine, this heat from the substances in the refrigerator is transmitted to the expansion pipes by the brine. Here there is no forced circulation as in the brine circulating method. While this system gives some reserve capacity the expansion coil and tank occupies more room in the refrigerator than in the direct expansion method.

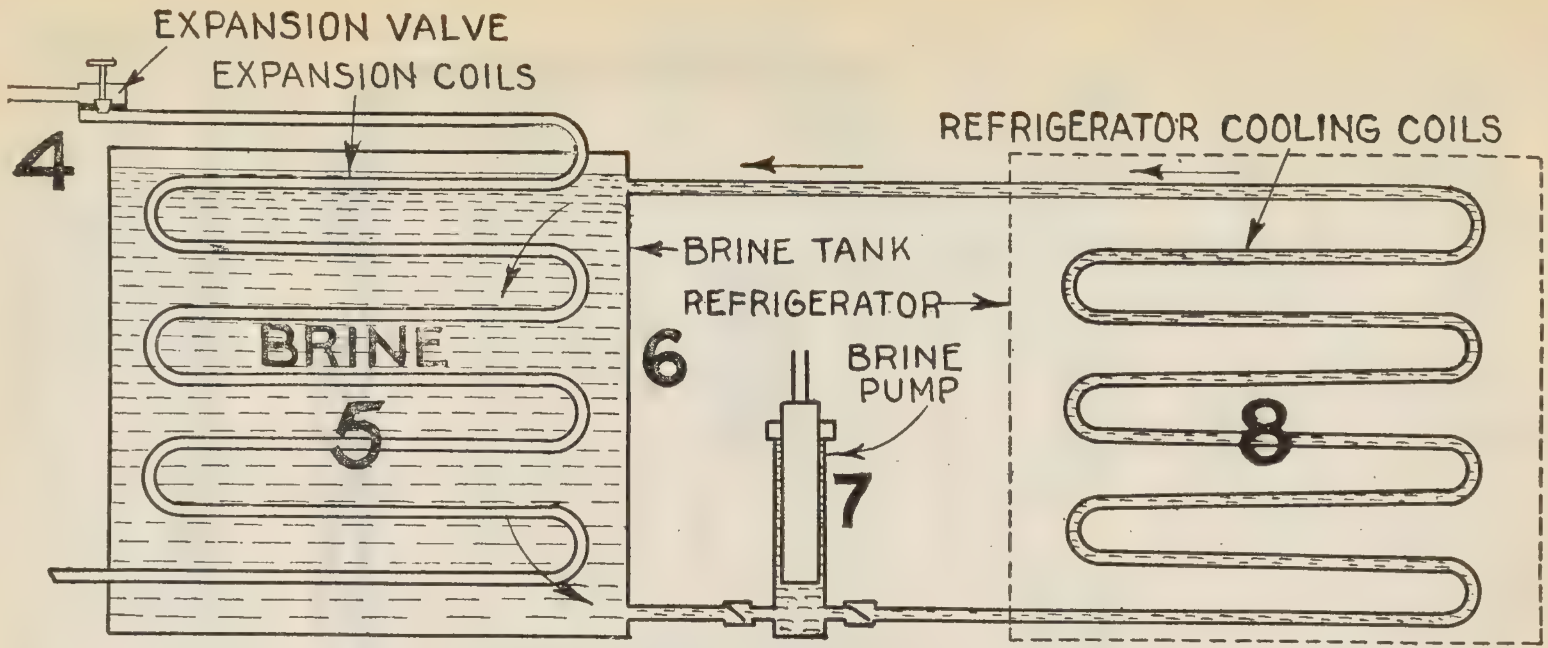


FIG. 8,659.—Elementary ***ammonia compression system*** *with direct expansion or brine circulation transmission.* This system consists essentially of the five elements shown in fig. 8,652, and the additional elements; 6, brine tank; 7, brine pump, and 8, refrigerator cooling coils as here shown. ***In this method*** the application of the refrigerating effect is indirect, that is the expansion coils whenever the cold is produced is not in direct communication with the substances to be cooled, the low temperature being transmitted to the space to be cooled or refrigerator by means of brine in circulation.

weak liquor, and the heat given up by the gas in the absorption process is carried off in the cooling water. The strong liquor or strong aqua ammonia resulting from the absorption of the ammonia gas is pumped into the generator where it is again driven out of solution by the heating coils, thus completing the cycle.

Methods of Applying the Refrigerant.—In applying the refrigeration medium to the space to be cooled there are several methods as:

1, By direct; 2, by brine; and 3, by air circulation.

In the *direct expansion* system the liquid ammonia is allowed to expand in pipes placed in the rooms to be cooled, and the process of expansion absorbs the heat in the surrounding atmosphere.

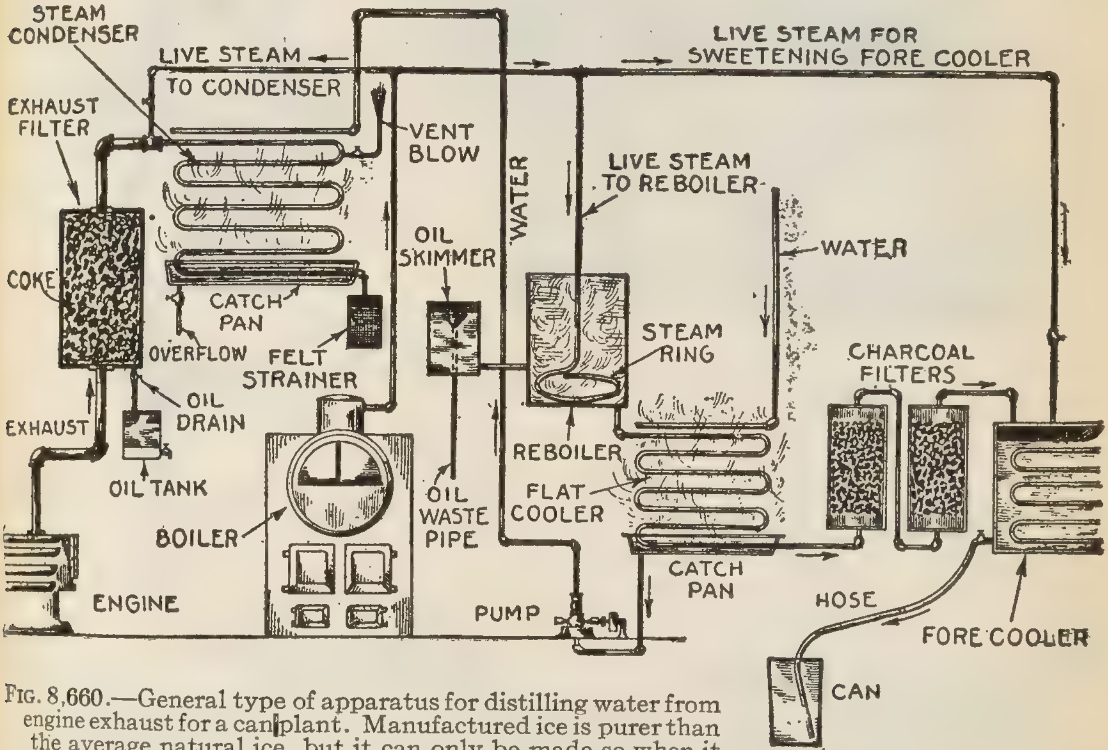
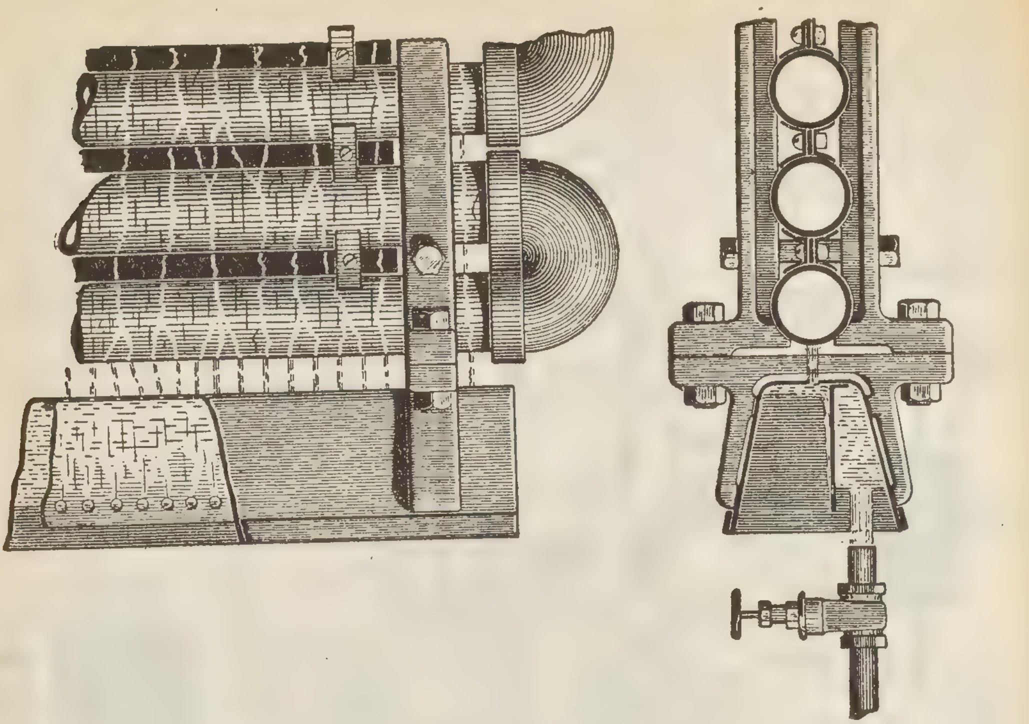


FIG. 8,660.—General type of apparatus for distilling water from engine exhaust for a can plant. Manufactured ice is purer than the average natural ice, but it can only be made so when it is made from pure water, and as the water that is put into the ice plant may contain the same impurities that any other water does, special apparatus for purifying it is essential. ***In operating*** the above apparatus, the boiler is filled with water, a fire is built under it, and steam is raised for running the engine at the left, although the steam pipe from boiler to engine is not shown. After the steam is exhausted from the engine it passes through the exhaust filter, which is filled with coke and from thence into the steam condenser. A live steam pipe also discharges into this condenser, so that when the exhaust steam does not furnish sufficient water more may be added in this way. Having passed through the condenser the steam is changed into water by the action of cold water flowing over it, after which it goes to the felt strainer and to the oil skimmer where all of the cylinder oil is removed and it goes to a tank where it is reboiled by means of a live steam pipe, and thence passes to the flat cooler as shown. It then passes through charcoal filters and to the fore cooler and when it comes out of the faucet and goes through the hose to the can, it may be considered clean.

In the *brine circulating* system, instead of the pipes being placed directly in the rooms to be cooled, the expansion coils are placed in an insulated tank of brine. The expansion lowers the temperature of the brine, which remains in a liquid form at temperatures far below the freezing point of pure water. This cold



FIGS. 8,661 and 8,662.—Condenser coils with trough and strips between pipes to prevent splattering of the cooling water.

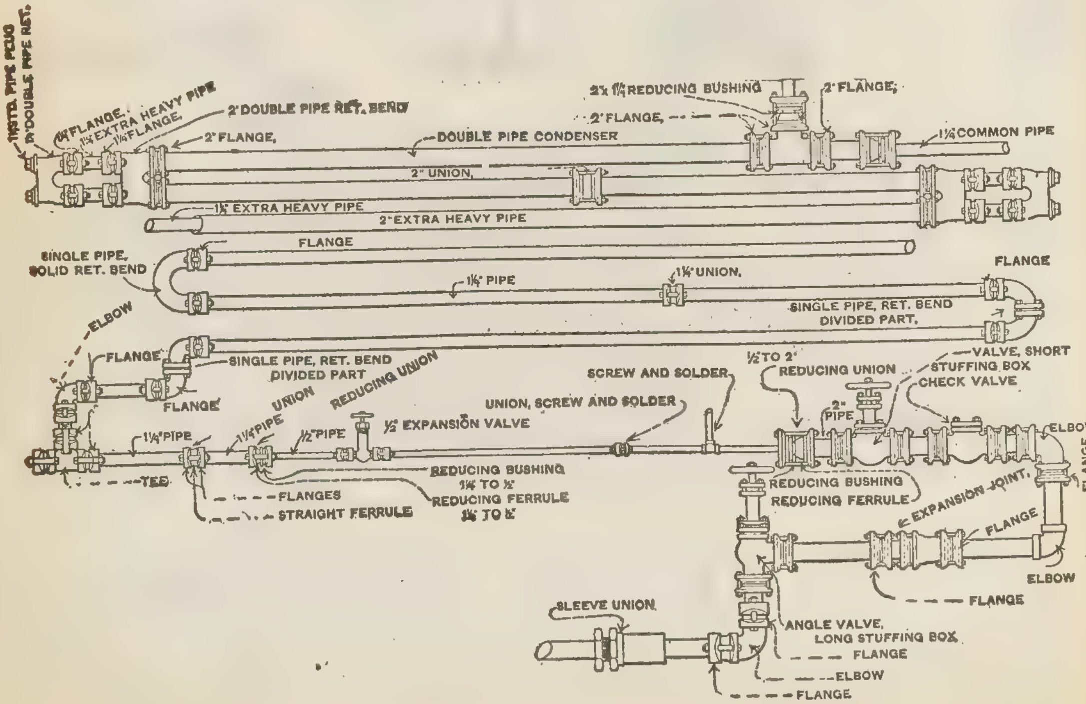
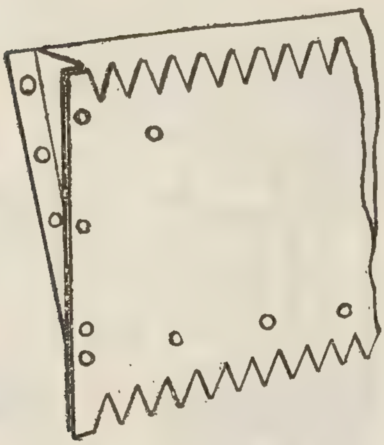


FIG. 8,663.—Different connections made with ammonia fittings.

brine is then pumped through pipe coils in the rooms to be cooled, and returns to the tank to be used over and over.

The brine system possesses a marked advantage under certain conditions. For instance, where it is desired to run the compressor only a part of the day, the brine pump is kept running continually, thus circulating the cooling fluid. Also where there are many small rooms or boxes to be cooled it is difficult to control the temperatures with the small amount of piping in each



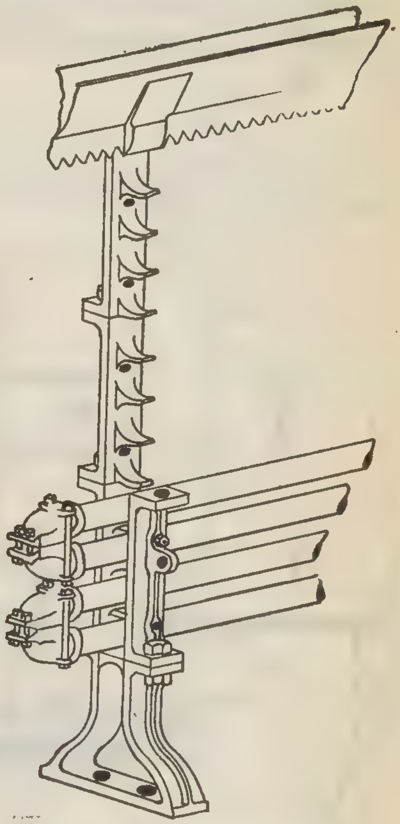


FIG. 8,664.—Atmospheric ammonia condenser trough. The saw tooth edge of the metal distributes the water evenly along the pipe and prevents splattering.

FIG. 8,665.—Atmospheric ammonia condenser pipe stand with dripping trough.

room and a separate expansion valve, but with the constant circulation of the brine, the temperatures are perfectly regulated.

Both the direct expansion and the brine circulating systems are used in the manufacture of ice.

In the *air circulating* system the expansion coils are placed in an insulated box or room, through which the air is drawn

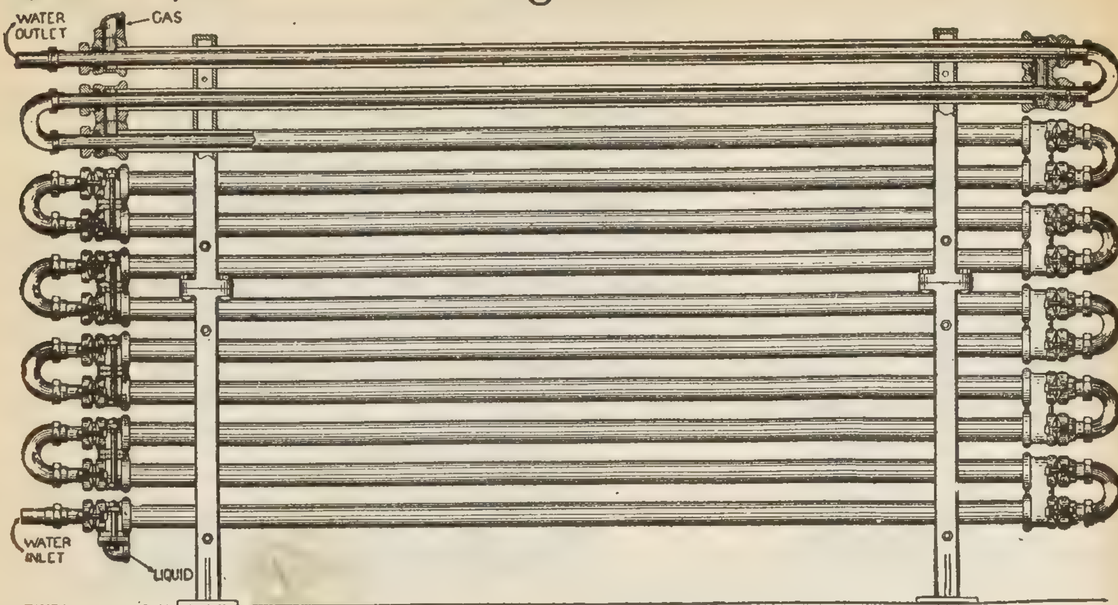


FIG. 8,666.—Double pipe ammonia condenser. The gas enters at the top in the annular space between the outer and inner pipes, the liquid being drawn off at the bottom. The inner pipes are for the water, and thus the counter current effect is easily obtained.

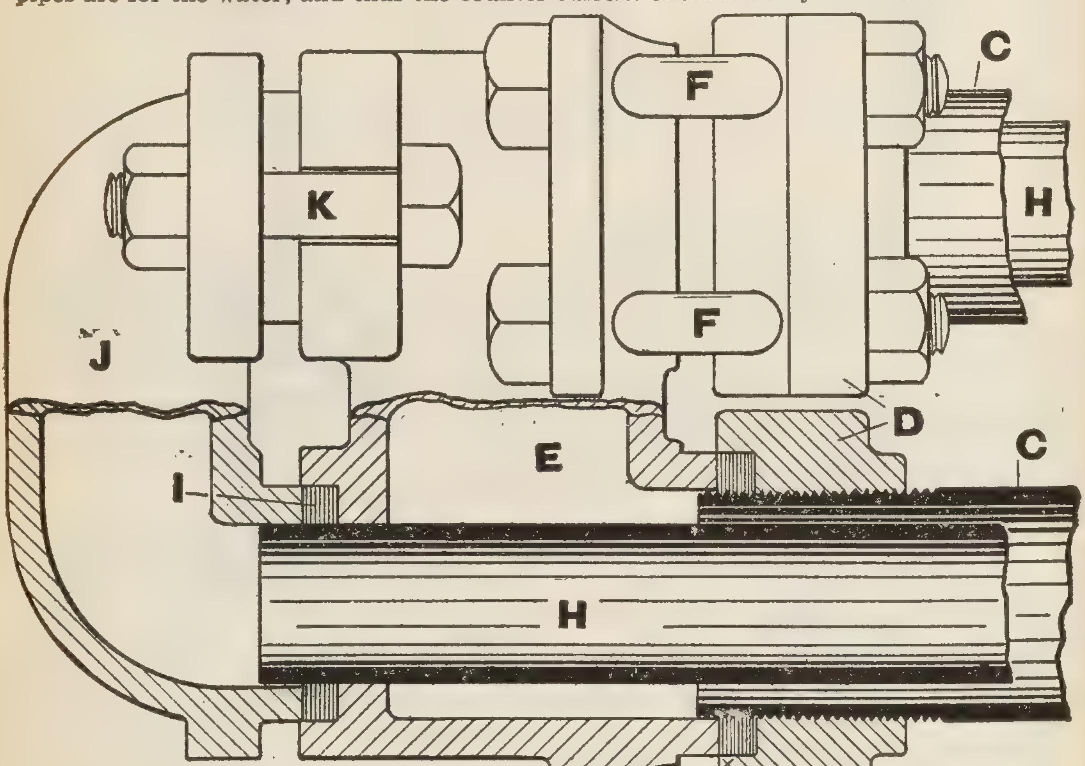
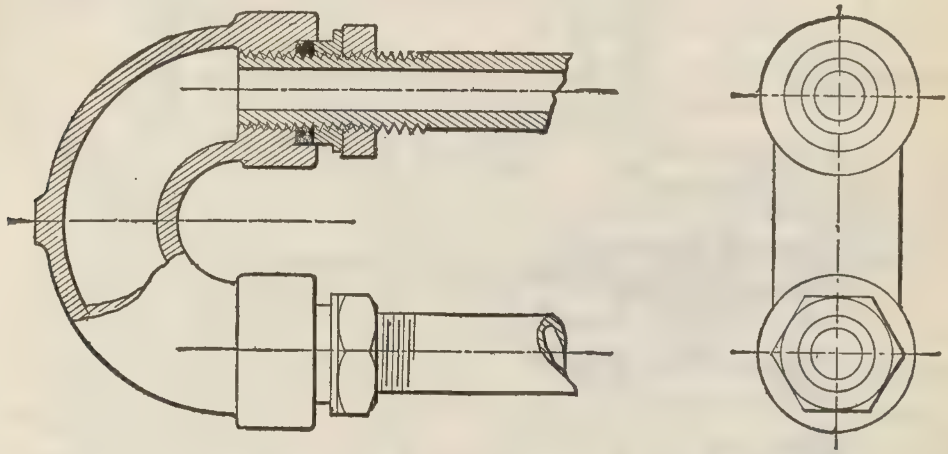


FIG. 8,667.—Detail of double pipe return bend. The ammonia pipes C, C, are screwed into the flanges D, and to these flanges the casting E, is held by the bolts F, F, compressing the soft packing G. The inner pipes H, H, are for the water circulation, the joints being made tight by means of the soft packing rings I, around each end of the pipe, which are compressed by the return bend J, and the bolts K.

to be cooled by passing over the coils and is then distributed to the cooling rooms, returning through ducts to the pipe room to begin the circuit again. It is not well adapted where a very low temperature is required, but an even temperature and a dry atmosphere can be successfully maintained. This system is used only in cold storage warehouses.



FIGS. 8,668 and 8,669.—Solid return screw joint bend with recessed ends, showing method of using latter as stuffing boxes to insure tight joints.

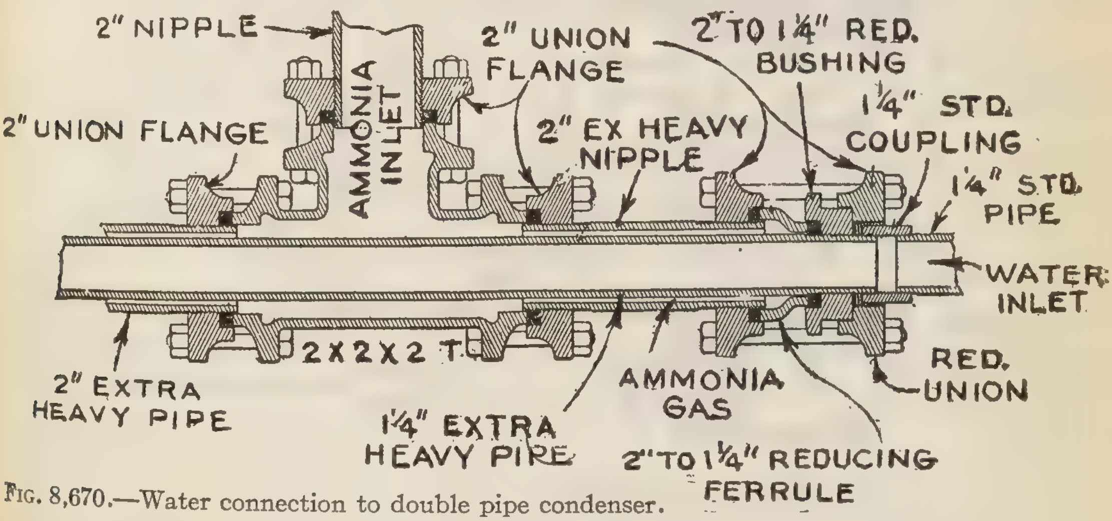


FIG. 8,670.—Water connection to double pipe condenser.

In deciding which of the above systems to use the purchaser must be governed by the conditions of his particular case. A system found efficient and economical in one industry may not be best in another. Or, sometimes, as in cold storage plants, all

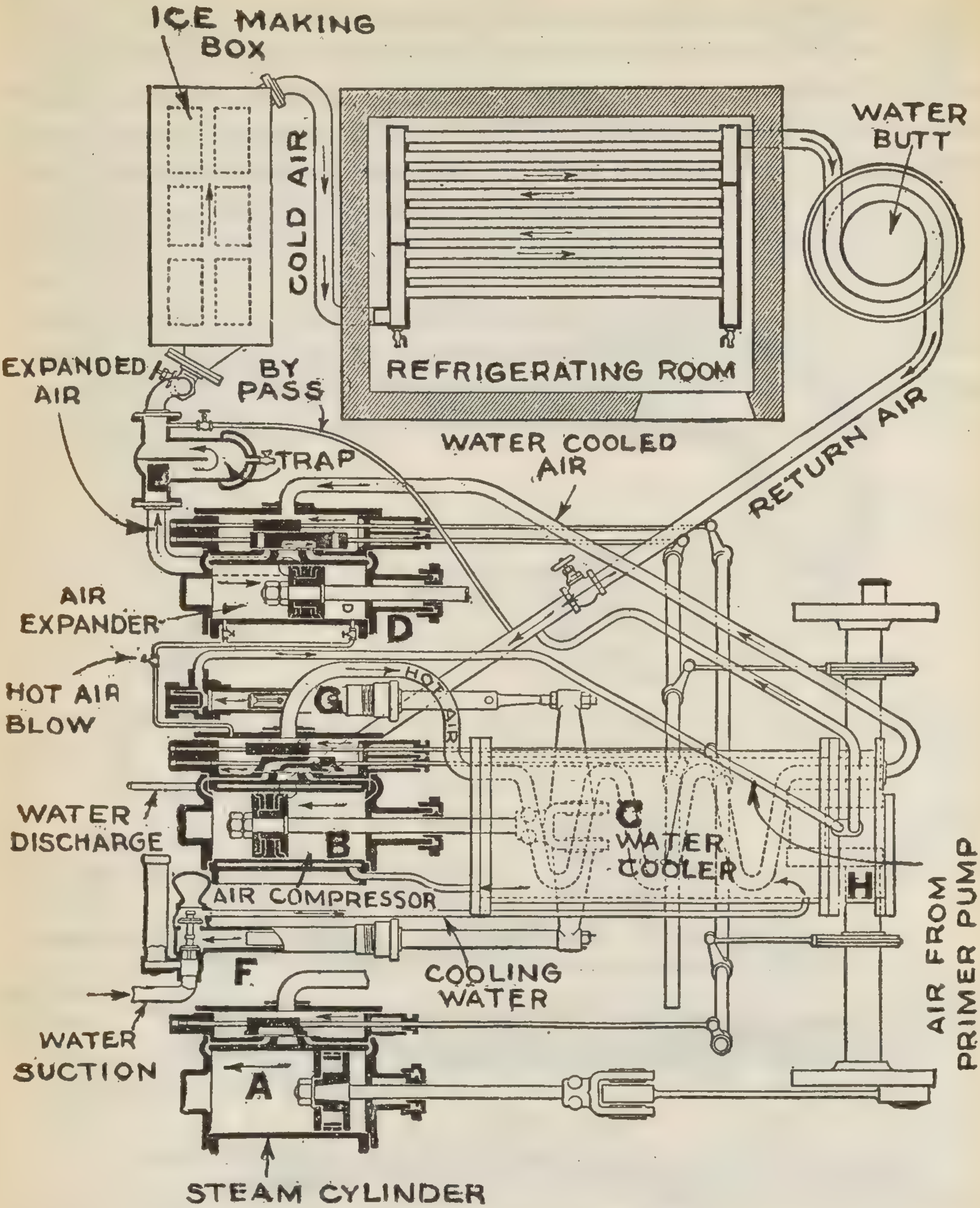


FIG. 8,671. Diagrammatic plan view of Allen dense air machine. The following are the important parts: A, The steam cylinder which furnishes the power to its crank shaft, to which the air compressor and the expander are linked. The letters refer to the opposite diagram. B, The air compressor cylinder which compresses the air to about three times the entering pressure. As this causes the air to heat, the cylinder is surrounded by a water jacket to make lubrication practicable. The compression cylinder is constructed with slide valves, instead of the usual conical lift valves, in order to move more quickly and noiselessly. C a copper coil in a bath of water; the compressed hot air in passing through it cools to the

these systems are used, the refrigeration being furnished by a single machine.

Cold Air Machines.—Under a well-known law *compression* exerted on air increases its temperature, and during its *expansion* cold is created to about the same amount.

The machines used in the air process consist of, 1, an *air compressor*, and, 2, an *expander*; the former compresses the air

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*NOTE.—In the ***Allen dense air*** machine, where the same air is used over and over again, additional moisture can only come from the small make up air supply, and most of this is removed by the trap provided for this purpose. ***In operation*** this trap should be watched in order to make sure that its action is efficient and that there is no danger of the passage of water over into the expansion system. In routine operation it is usually desirable to clean the machine by heating it up and blowing out all the oil and ice deposits. To this end the valves in the main pipes leading the air to and from the coils are closed, thus shutting off the machine from the remainder of the system. A by pass is then opened, connecting the main expansion pipe beyond the oil and snow trap with the main return from the coils. Connections are then opened in the so called hot air pipe leading from the compressor cylinder to the expansion cylinder, and the expansion inlet valve is partly closed. Live steam is then let slowly into the jacket of the oil trap in order to thaw out all ice and hardened oil, and the machine is run moderately for a time, during which the blow off valves of the trap and expansion cylinder are frequently opened until everything appears clean. Then the machine is readjusted to its normal condition and run as before. If it should be suspected that any considerable quantity of oil and water have gotten into the pipe system and are clogging the surfaces, the pipes may be cleaned by running hot air through them and drawing off the oil and water at the bottom of the manifolds of the refrigerating coils.

FIG. 8,671.—*Text continued.*

temperature of the water. The return air cooler which still further reduces the temperature of the air. D, The expansion cylinder, to which the cooled compressed air is admitted until it fills one-third of the volume of the cylinder. The air supply is then cut off, and as the piston makes its full stroke to the end of the cylinder the air expands until the tension is about normal, and the expansion cools the air about as much as the compression heated it. It is constructed like a usual steam engine cylinder, with slide valve and cut off valve. It must cut off the pressure at such a point that the expanded air at the end of the stroke of the piston is very nearly of the same pressure as the air contained in the system of pipes. If it were of much higher pressure it would, at exhausting, warm up again, by exerting its remaining power in producing velocities and frictions inside of the apparatus. The air, therefore, leaves this cylinder at a very low temperature and is discharged into a well insulated pipe which conveys it to the point of use; there the pipe is exposed and the cooling is effected, the air returning to be used over. The expander helps the steam cylinder and the air compressor takes the power. E, is a trap placed just after the expander which intercepts any oil and snow; the trap is provided with a heating pipe and the contents of the trap should be drawn off every few hours. The machine is so arranged that at the same time any frozen deposits in the expander cylinder can be thawed and blown into the trap. F, is the water pump which circulates water around the copper coil C, and through a water jacket which surrounds the working cylinder of the air compressor B, in order to prevent the heat injuring the packings. G, is a small air compressing pump which takes air from the atmosphere and pushes it into the machine and pipe system. This charges the system with the requisite air pressure when the machine starts to work, and maintains the pressure against leakages occurring at the stuffing boxes and joints. This air, of course, contains the usual atmospheric moisture, and to expel this, the outlet pipe from this pump passes the air through the trap H.

and passes it into a cooling coil of pipe surrounded by circulating water; this removes the heat of compression and the compressed cool air is then passed into the expander.

The *expander* or *expanding engine* of a dry air machine consists essentially of the same principal parts as a regular cut off steam engine: viz., cylinder, piston and slide-valve.

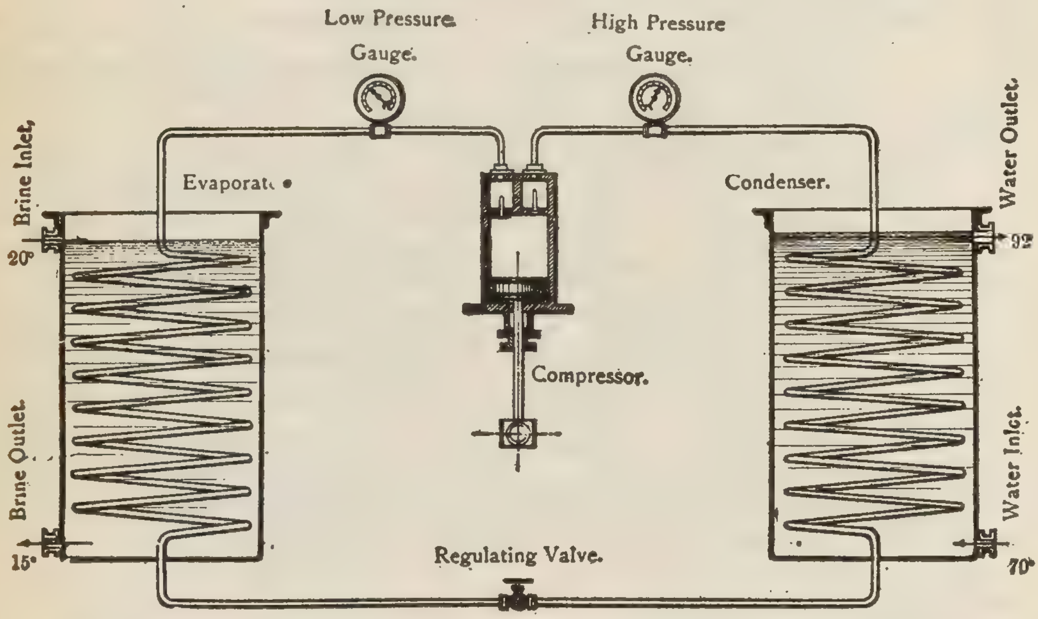


FIG. 8,672.—Carbonic acid system with brine circulation. ***It consists essentially of*** an evaporator, compressor and condenser. ***In operation.*** the heat required for evaporation is furnished by brine which surrounds the pipes, or by air. The gas, as it leaves the compressor passes into a separator where the glycerine impinges against the sides of the vessel and adheres to it as it has no affinity for carbonic acid; the glycerine then falls to the bottom of the separator and is drawn off from time to time, while the gas passes on into the condenser.

The cold compressed air from the cooler is admitted during a portion of the stroke of the piston, its supply being regulated by the slide valve, and the air in the cylinder is expanded as the piston proceeds to finish its stroke.

On what corresponds to the exhaust stroke, the expanded air is next forced through the conveying and refrigerating pipes to the cold room, where it remains inside of pipes and does its refrigerating. These processes of *compression*, *cooling* and *expansion* are continually repeated, the same air circulating through the plant over and over again.

This type of machine requires considerable room, which cannot be well spared on shipboard, and the moisture in the air, when its temperature is reduced, becomes snow and ice and makes more or less trouble by clogging valves, etc.

CO_2-System.—Carbonic acid (CO_2) is a gaseous compound of carbon and oxygen, colorless and without smell; it may be reduced to a liquid by high pressure and cold; it has a pleasant, pungent taste, and aerated beverages of all kinds, like soda water, etc., owe their refreshing qualities, in part, to its presence.

In the machines in which carbonic acid is used, the cycle of operation is as follows: first, a compression of the gas in a powerful pump, called a compressor, which raises its temperature; second, the hot gas then passes into coils of pipe over which cold water is allowed to run, this carrying away the heat and liquefying the gas; then the latter passes to the refrigerating rooms and through an expansion valve which allows it to expand in the refrigerating coils and take up the heat of the surrounding atmosphere. It now returns to the compressor and the cycle is complete.

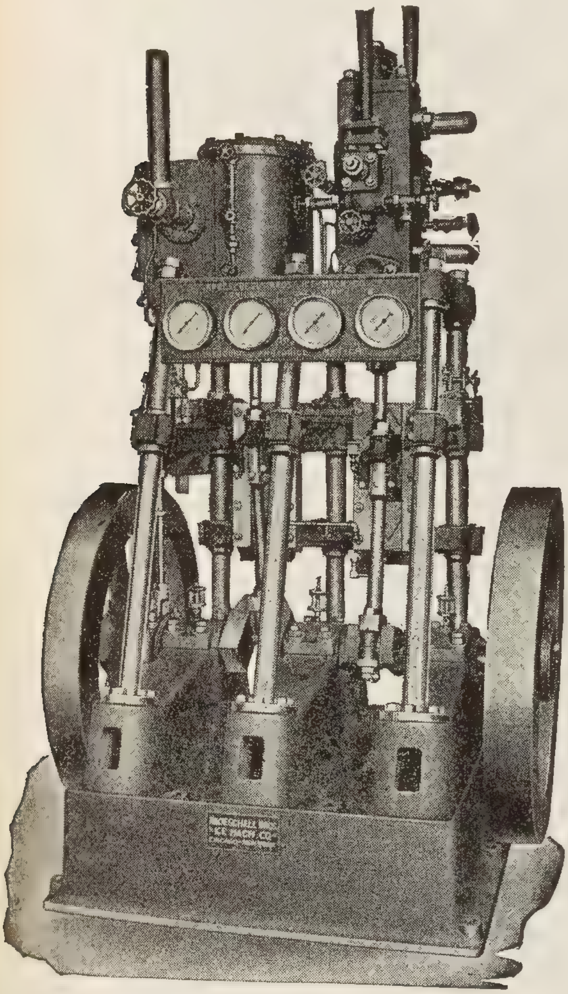


FIG. 8,673.—Kroeschell vertical double-acting steam marine type carbonic anhydride (CO_2) compressor. ***In construction,*** the cylinders are cast in a solid block, the bore, valve chambers and valve ports being machined in the block. As the entire cylinder is made in one piece, and all valves are placed directly in the cylinder, there are no joints in the bore over which the piston must travel. The discharge pressure in the cylinder varies from 50 to 80 atmospheres depending upon the requirements. A safety valve is placed in the high pressure channel between the discharge valves and the discharge stop valve. The purpose of this valve is two fold. It will relieve the cylinder also the refrigerating system, of a pressure that has risen above the normal, in case of fire or through lack of condenser water, and it will also guard against carelessness of the operator were he to start the compressor in operation without first opening the discharge stop valve. As the opening of the safety valve is accompanied by a loud report, it will direct the attention of the operator to the compressor. When the excess pressure has been relieved and the pressure in the cylinder again becomes normal, the safety valve closes automatically. The safety valve is designed to blow off at a pressure considerably below that to which the compressor and other refrigerating equipment has been tested.

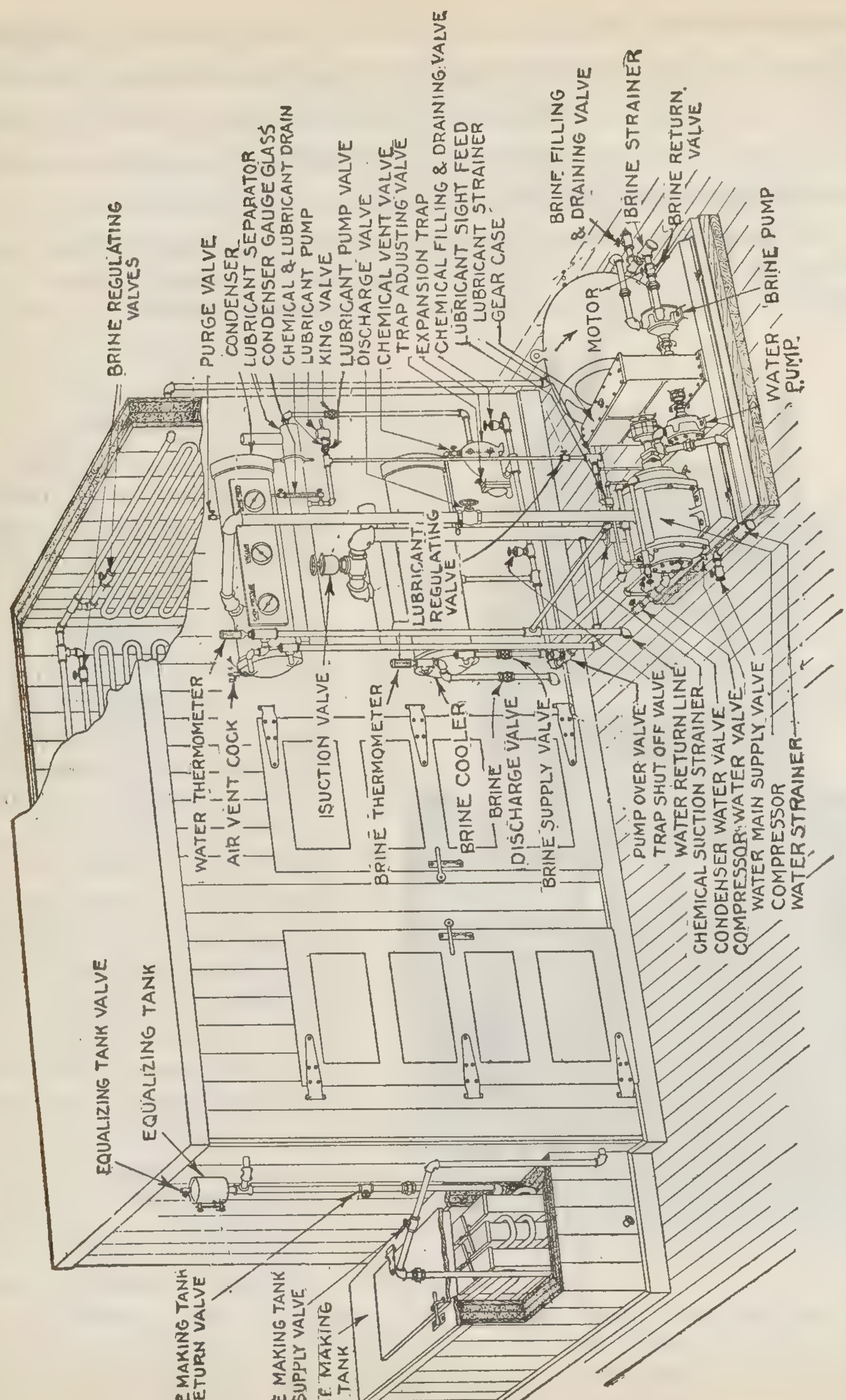


FIG. 8,674.—Typical installation of Clothel ethyl chloride system.

As compared with ammonia, which is much more extensively used for refrigerating purposes, carbonic acid is cheaper; it is non-corrosive; non-explosive; not dangerous to life, nor harmful to food products.

It has also no affinity for copper, hence that metal may be used for condensers when sea water only can be had for cooling.

Mechanical Ice Making.—The term "mechanical ice making" as here used relates to the apparatus and methods employed

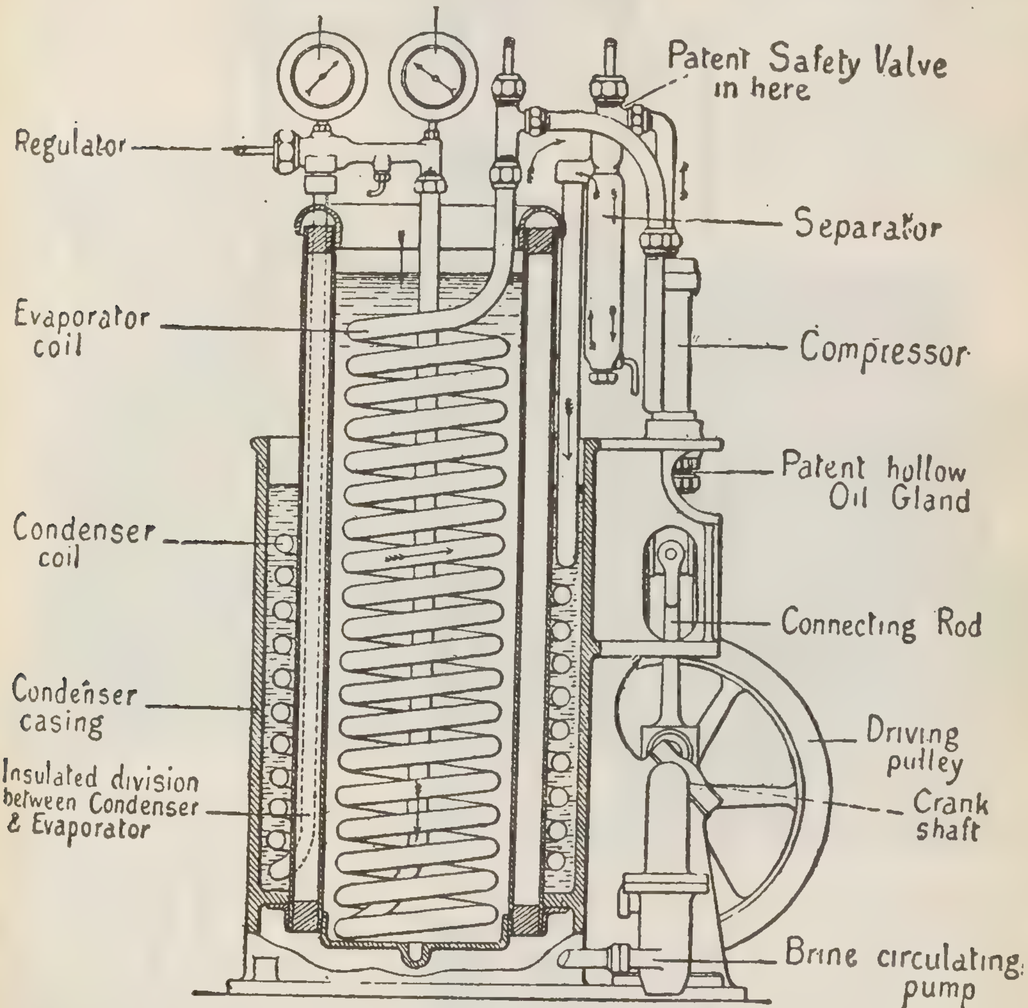


FIG. 8,675.—Hall marine carbonic acid refrigerating machine. The compressor is directly attached to the body of the condenser which is of the submerged type. The cooler consists of a shell concentric with the condenser, well insulated from same, and containing the evaporating coil. The condenser coil connects with the evaporator coil through the expansion valve shown at the top within easy reach, and each coil is provided with a pressure gauge, the one at the right being the low pressure and at the left, the high pressure gauge. The brine is circulated through the cooler by means of a small brine pump attached to the crank shaft.

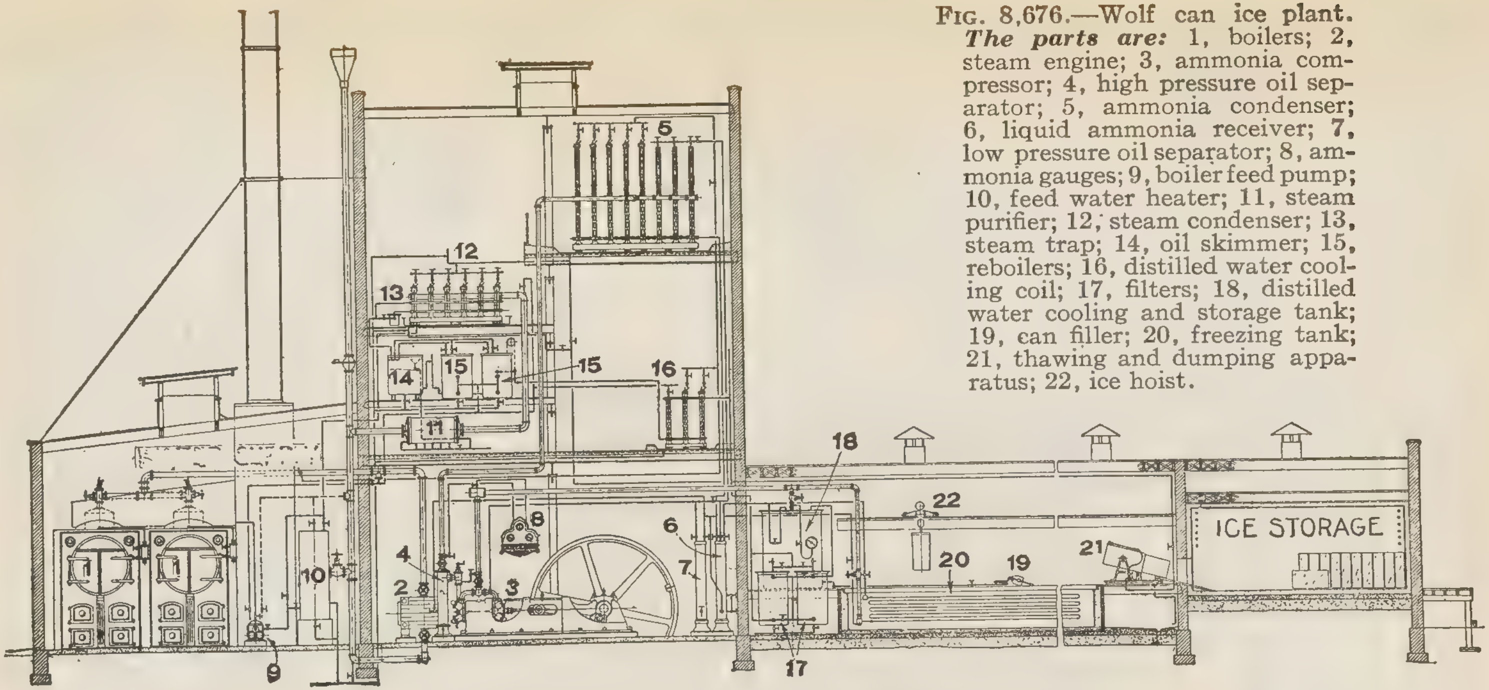


FIG. 8,676.—Wolf can ice plant. *The parts are:* 1, boilers; 2, steam engine; 3, ammonia compressor; 4, high pressure oil separator; 5, ammonia condenser; 6, liquid ammonia receiver; 7, low pressure oil separator; 8, ammonia gauges; 9, boiler feed pump; 10, feed water heater; 11, steam purifier; 12, steam condenser; 13, steam trap; 14, oil skimmer; 15, reboilers; 16, distilled water cooling coil; 17, filters; 18, distilled water cooling and storage tank; 19, can filler; 20, freezing tank; 21, thawing and dumping apparatus; 22, ice hoist.

in freezing ice into cakes for distribution by ice wagons. There are two methods known as

1. The can method;
2. The plate method,

the former being the more extensively used.

In the can method, galvanized cans or moulds are filled with water, after they have been suspended the proper depth in a tank of brine, the brine being cooled by a direct expansion in the freezing tank.

The time required for freezing varies from 40 to 60 hours, depending on the thickness of the cakes. The longer the time a given thickness is allowed to freeze, the better the quality.

In removing the cakes from the cans, the cans are drawn out of the brine and sprayed with, or dipped into, warm water which loosens the ice so that when the can is inclined on its side the cake of ice slides out, the can being made tapering in shape so as to facilitate the movement.

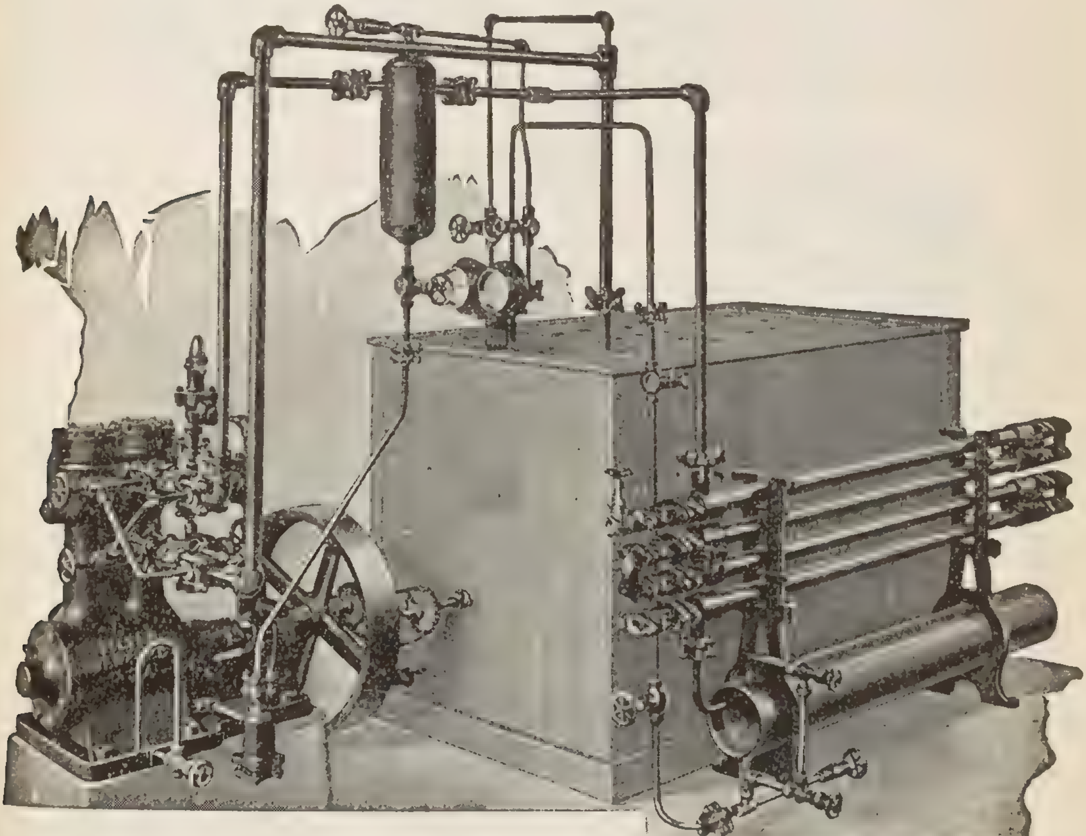


Fig. 8,677.—Vilter small can ice plant; capacities 1,000 to 6,000 lbs. ***Compressor,*** vertical single acting belt driven type with by pass between main suction and discharge stop valves permitting reversal of compressor action so that entire charge of ammonia can be pumped from condenser and stored in the freezing coils, or vice versa, when it is desired to examine or make repairs to either the *h.p.* or *l.p.* side of the plant. ***Oil separator,*** horizontal type connected in discharge line leading from compressor to remove oil from the hot discharge gases before they pass into the condenser. The freeze valve at the bottom of separator is used for draining off any accumulated oil. ***Condenser,*** double pipe type attached to side of freezing tank, cooling water entering at the bottom circulates through the inner pipes, while the hot ammonia gas entering at the top, traverses the annular space between the pipes and passes as a liquid to the receiver below. The blow off valve at highest point permits blowing off any non-condensable vapors from condenser. ***Liquid receiver,*** seen below condenser, it is for storing liquid ammonia from condenser. ***Freezing tank and coil;*** the number of cans is such as to permit slow freezing. Coils are in loop form, made from one piece of pipe. A valve is provided to blow air, oil or scale from the coils, or charging the system with liquid anhydrous ammonia. ***Brine agitator,*** is of horizontal type and usually driven by link belt chain from a sprocket on compressor shaft. It circulates the brine to maintain a uniform freezing temperature throughout the tank.

One man with a hoist can handle from ten to fifteen cans per hour.

The cans are filled with a can filler which is so constructed as to automatically shut off the water supply when the can is filled to the proper height. The filler is inserted in the can and the water turned on. As the can fills the ball floats and rises until the can is filled to the right depth, when the valve is automatically closed.

The depth at which the brine is carried in the freezing tanks is an important feature in obtaining the quantity of ice the machine is capable of making. The brine should come as close to the top of the can as possible, and should be somewhat higher than the water in the can, since allowance for expansion as the water freezes is made when the cans are filled. Cans

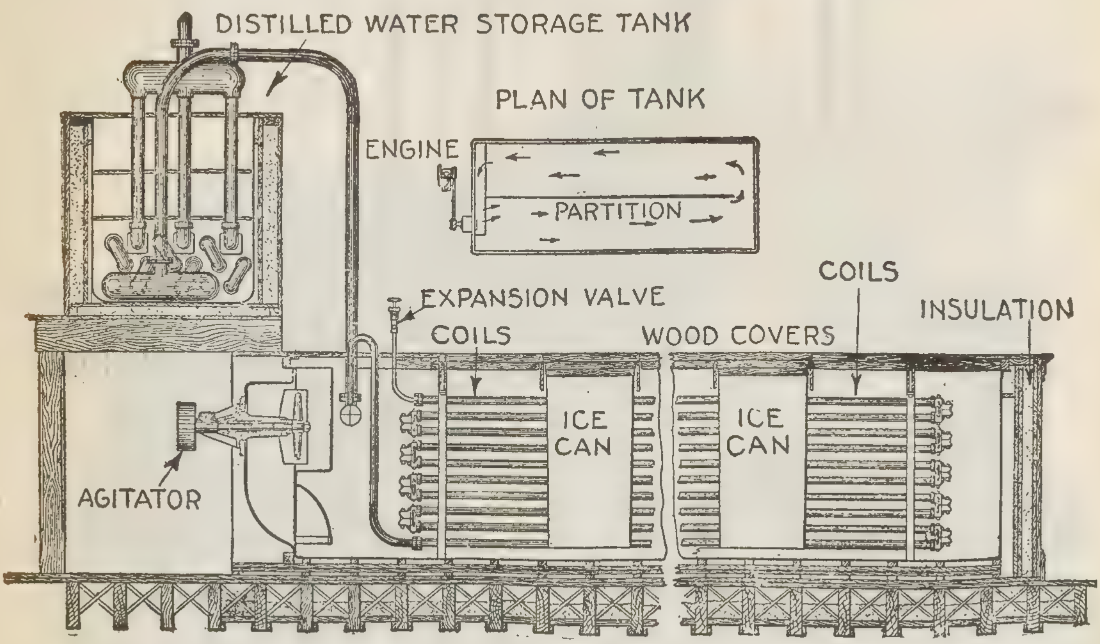


FIG. 8,678.—Detail of freezing tank of an Eclipse ice plant, showing the arrangement of the cans with covers, also the brine agitator. The agitator is in the shape of a propeller which keeps up a continuous circulation of brine between bottom and top of tank.

that are properly filled with water will be even full of ice when frozen. It may take some experimenting to find the exact quantity of water required, but the time and trouble will be more than paid for in the increased yield.

A red core which is occasionally seen is due to the presence of carbonate of iron which may come from scale on the pipes and which impregnates the steam, thence appearing in the center of the ice cake.

NOTE.—The cloudy or milky appearance of an ice cake is due to the presence of air. This may be due to deficient re-boiling, the overworking of the re-boiler, or more likely than either, to an insufficient supply of steam to the distilled water condenser, in which case the rapid condensation of the steam causes a vacuum and air is drawn in.

Plate Method.—In this method several vertical hollow iron walls are built in a large tank. The tank is filled with pure well water so that the iron walls are entirely submerged. The hollow iron walls are placed parallel to each other at a distance of from two to three feet. The freezing fluid, consisting either of cold

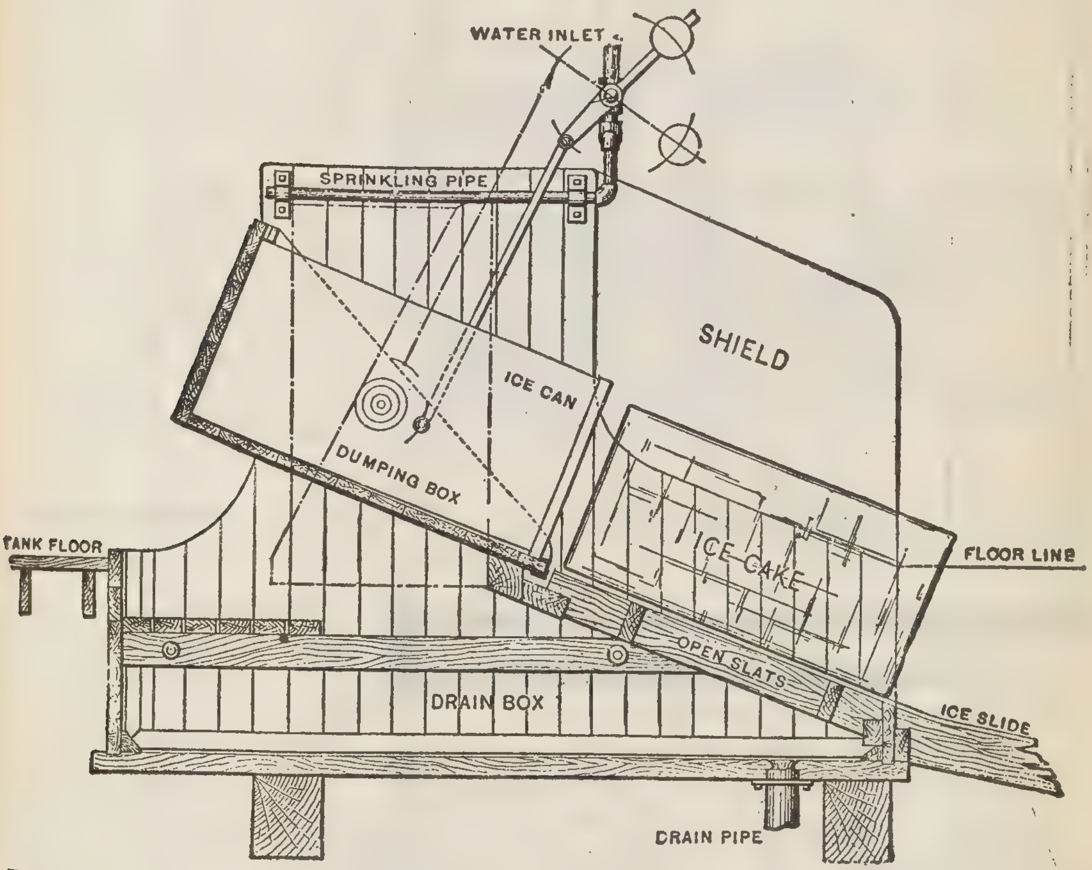
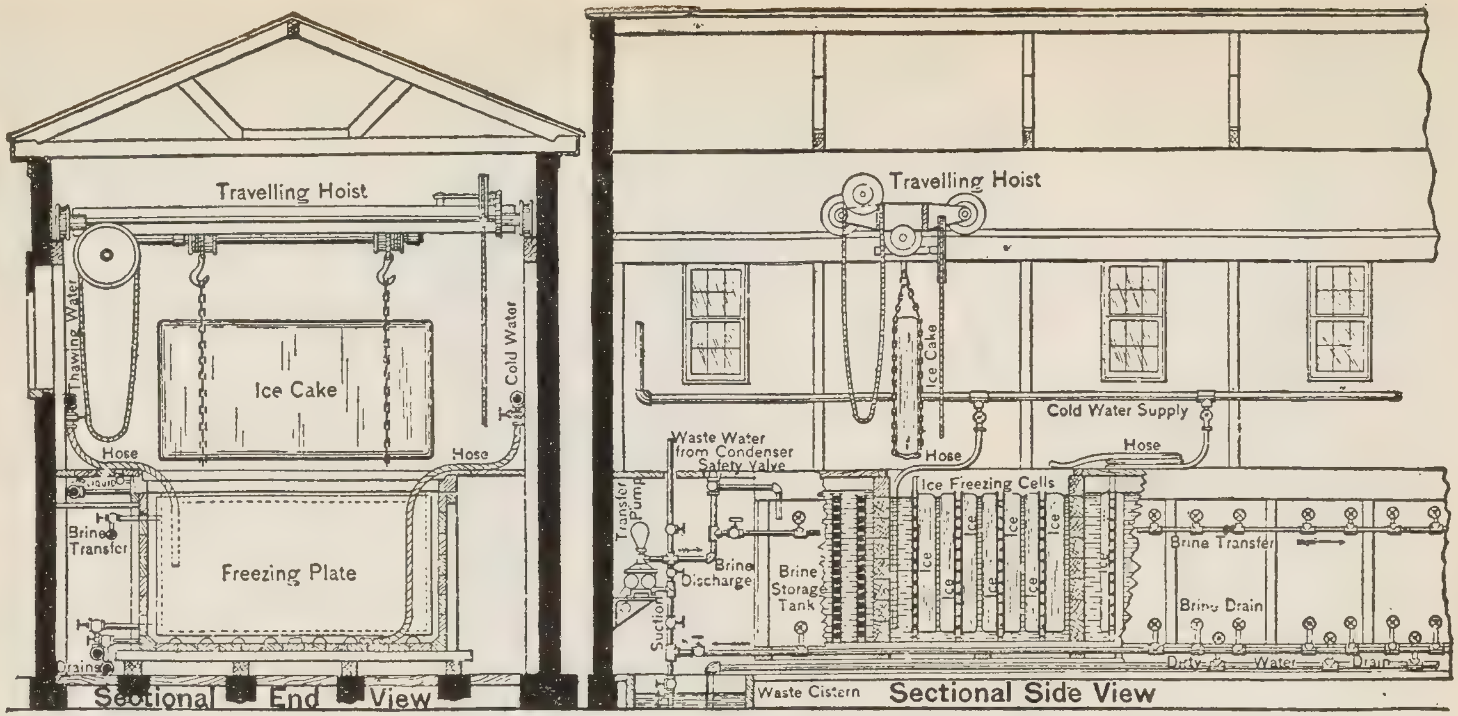


FIG. 8,679.—Sectional view of a can dumper. The dumping box is connected by a link to the valve in the sprinkling pipe, thus as soon as the box is turned into the position shown the valve automatically opens, and hot water is sprinkled over the can and the cake of ice is thus loosened.

brine or ammonia, is passed through the hollow walls, with the result that the water will freeze on the outside of the walls; the water is kept in agitation either by means of a propeller or pump, or by compressed air, so that the water is kept continually on the move; carrying the air with it prevents it being frozen in the ice. After the ice is frozen on the walls to the



FIGS. 8,680 and 8,681.—Eclipse plate ice plant showing sectional view of freezing cells. The ice plates are hoisted by means of the traveling hoist after being thawed off the freezing plates by passing hot brine through the coils. The freezing plates with their coils are shown in heavy black lines with the ice forming on both sides of them.

required thickness, the freezing fluid is shut off from the walls and a warm fluid passed through instead until the ice is loosened and taken out of the tank.

The construction of the plate walls differs according to the freezing fluid used. If cold brine be used, then the brine has to be cooled in a separate refrigerator from which it is pumped through the walls and back to the refrigerator, the same as is done when cooling rooms by means of brine pipes. The plate walls in such a case are generally constructed of iron.

On account of the expansion and contraction occasioned by warm or cold brine being passed alternately through the hollow walls, it is very difficult to keep them tight.

If ammonia gas be used, the walls are built up of expansion pipes, which, connected at each end by return bends, make one continuous zig-zag coil. To get an even surface the coils are covered with thin iron plates on the outside of which the ice is frozen. Loosening the ice, when thick enough, is effected by shutting off the cold ammonia gas and passing hot gas through the pipes instead.

Agitation of the water in the plate method is accomplished by means of air jets located midway between the plates, sometimes in the center, sometimes three or four feet from one end and sometimes at both ends of the plates.

The harvesting of plate ice is similar to the methods employed with can ice, excepting that in use for harvesting block ice. Some use hollow lifting rods and thaw them out with steam, others use solid rods and cut them out when cutting up the ice, and others again use chains which are slipped around the cake when it floats up in the tank.

The advantage of plate ice over can ice is that, since the water is not confined in a can, it will freeze clear, and for this reason it is not necessary to distill the water, it only being necessary to filter it.

Management of Refrigerating Machines.—Before starting refrigerating machinery, whether newly installed or after any considerable period of disuse, all piping and joints should be tested for leaks. This may be done, no matter what the system be, using the compression pump to compress air into the piping to whatever pressure may be considered suitable.

The seriousness of the leakage may then be estimated by the rapidity with which the pressure is lost after allowing the pump to stop. The larger leaks may be determined by the noise made by the escaping air. For the smaller ones the joints are sometimes covered with soap suds so that the escaping air may show itself by blowing a cluster of bubbles. After the points which may show leaks have received proper attention, the system should, for a considerable time, hold the pressure without sensible loss. In this connection, however, it must be remembered that the air as it leaves the compressor will be heated by the work of compression, and as it loses

NOTE.—To pass at one time cold and at another time hot ammonia gas through the same pipes can only be done by bringing the pipe walls alternately in connection with the expansion and the compression side of a refrigerating machine, that is to say, make the pipe walls act at one time as a freezer and at another as a condenser. To do this special valve connections have to be made, which are complicated, and (to avoid accidents) require careful handling.

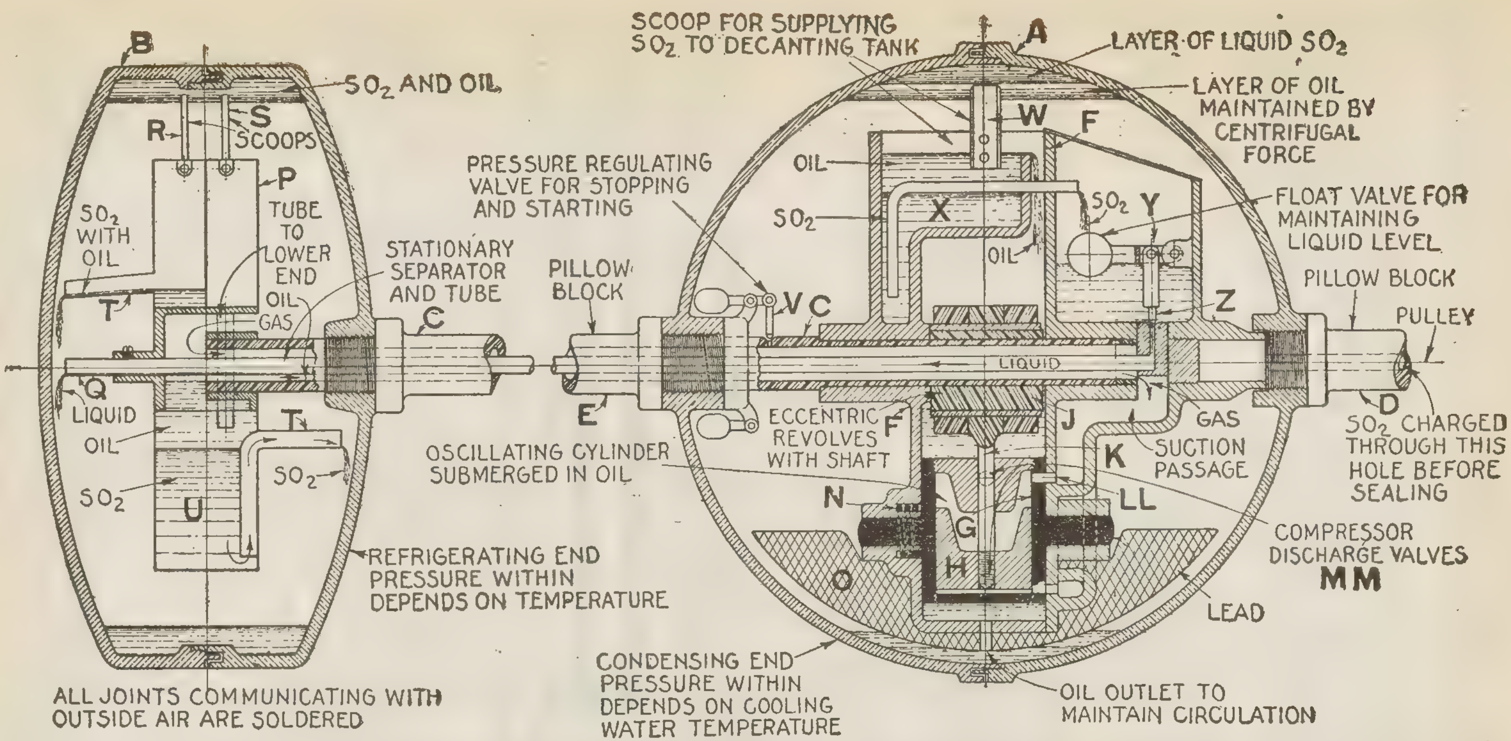


FIG. 8,682.—Sectional view of Audiffren ice machine showing mechanism. ***In construction,*** bells A and B, are hermetically sealed at all seams. Machine is charged at factory, after evacuation of air, with SO_2 and pure mineral oil. ***In operation,*** bells A and B revolve with hollow shafts D and EC. Carrier F, is held stationary by counterweight O, the shaft revolving within it. Carrier supports two oscillating compressors G. Compressors are double acting and driven by eccentric F. Vapor is drawn by motion of piston H, through hollow shaft and port LL, into cylinder. Return stroke compresses vapor, expelling it through spring valves MM, into the surrounding space. Vapor condenses upon walls of A, and collects with surplus oil at rim. Scoop W, carries mixture to decanting box X, oil overflows over bearing surfaces, and liquid SO_2 is delivered to reservoir Y. Expansion valve admits liquid to central tube Q, which is stationary with carrier F. Liquid is delivered to interior of evaporator B, and expands again to vapor under suction of the compressors. Spent gas returns through hollow shaft. Separator V and P, collects surplus oil carried over with liquid SO_2 and returns it in the stream of spent gas, to the condenser end. There is no chemical action, and no deterioration of the gas or oil. When machine is stationary, pressure in both bells is equalized through valve V, which closes by centrifugal force, isolating the condenser from the evaporator when running. Power required to compress the gas is derived through the shaft and eccentric. Torque created is resisted by weight of carrier assembly and counterweight, which rises about 15° from vertical. Variation in condenser pressure (and temperature) and variation of evaporator pressure (and temperature) directly affect torque required. If either brine temperature or condenser temperature becomes excessive counterweight will revolve and readjust pressures automatically.

this excess heat in the coils there will be a corresponding loss of pressure. After equality of temperature with the outside air has been reached, however, the further loss of pressure should not be appreciable.

With the air machine no further preliminaries are needed beyond the examination necessary to insure the proper mechanical condition of the compressor and steam cylinders. With the

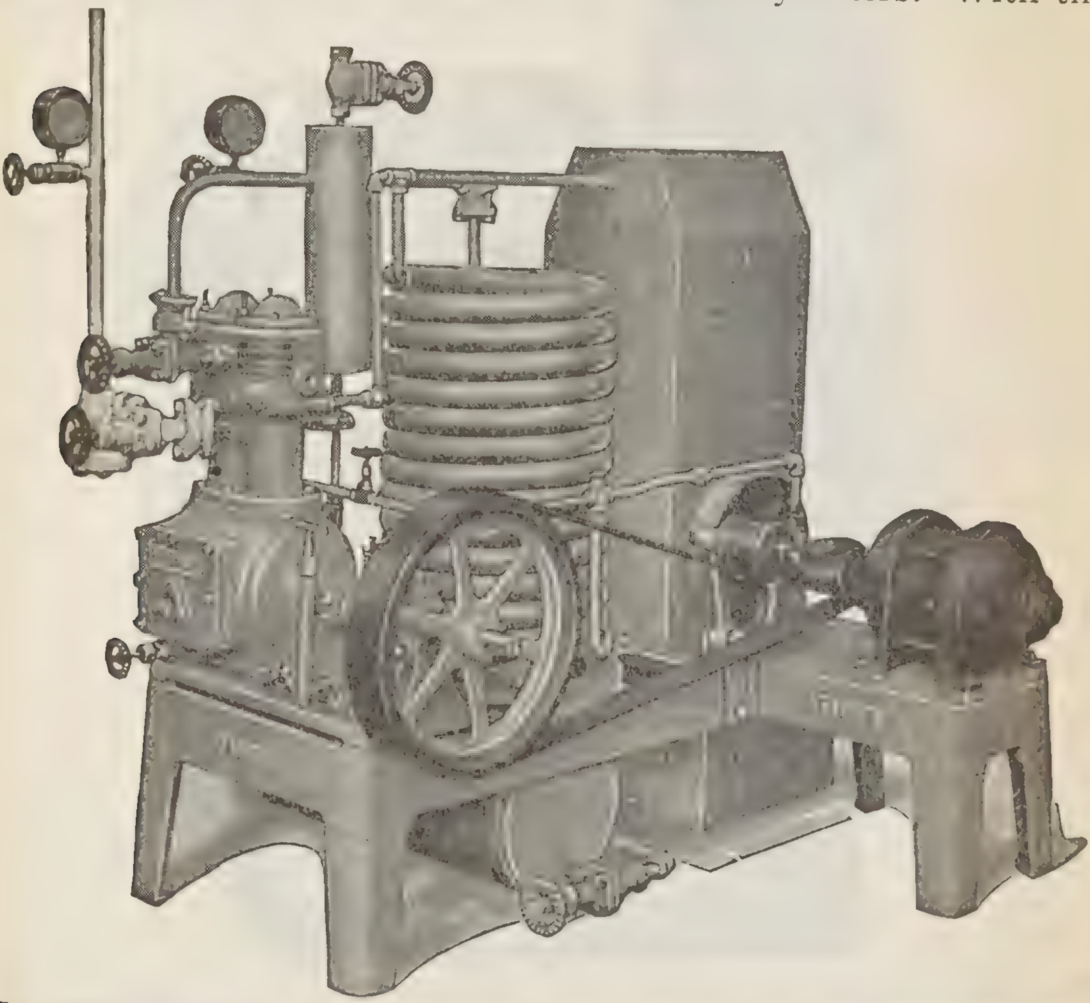


FIG. 8,683.—Fisher self-contained small ammonia refrigerating plant with condenser water re-cooling device. This unit which is suitable for small hotel or store service will pass through an ordinary door and can be moved anywhere with cooler, counter, or other fixtures.

ammonia machine, however, it is necessary next to exhaust the air from the entire system by working the pumps and discharging through valves provided for this purpose.

When the gauges show the highest vacuum which can be maintained,

the valves are closed and the system is ready for charging. The ammonia is usually provided in steel flasks containing a known weight of the liquid.

Refrigeration in the Home.—Every person who has ever been required to clean the slimy germ laden and filthy drain pipe of

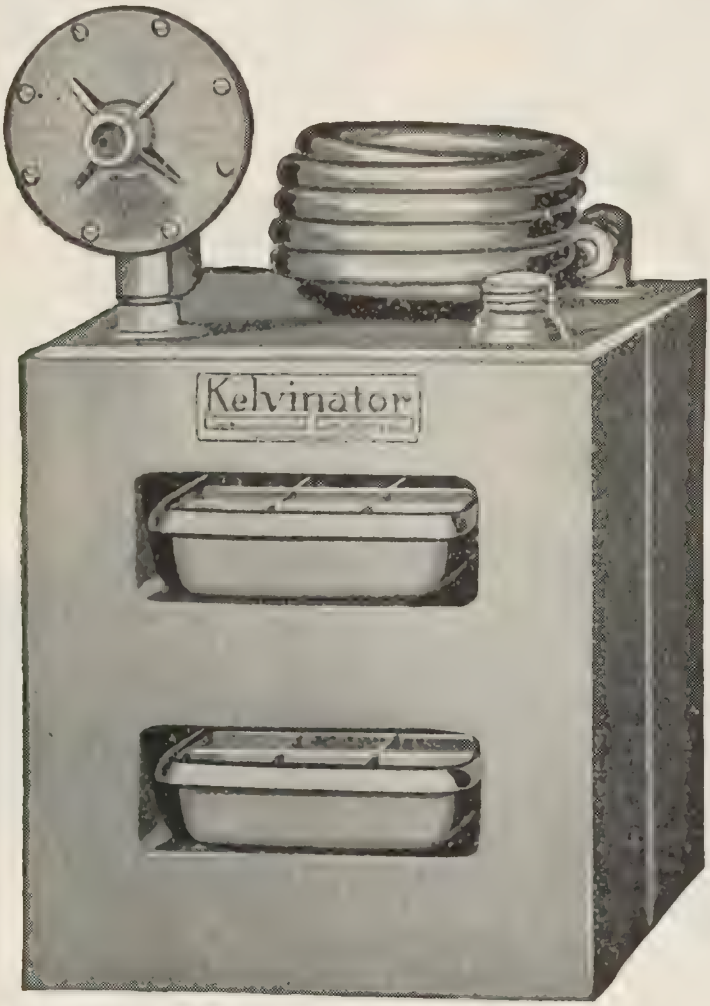


FIG. 8,684.—Kelvinator side icer freezing unit. Dimensions for 10 cu. ft. Capacity $10 \times 12 \times 11$ ins. (height tank only) $19\frac{1}{2}$ ins. high with expansion valve and thermostat. Two freezing trays capacity 42 ice cubes. Filter cap is located at highest point to prevent air pockets between freezing unit top and solution. The freezing unit is equipped with freezing compartments, the number depending upon the unit size. Expansion coils are placed within the freezing unit tank in such a manner as to surround each freezing compartment. The freezing unit tank is filled with a solution of calcium chloride of the proper density to prevent its freezing when temperature is down to approximately zero (Fahr.). This forms a storage reservoir for cold and reduces the number of motor starts per day. Kelvinator is automatically controlled by a make and break switch, thermostatically operated. This switch opens and closes the motor circuit, as the temperature within the refrigerator rises and falls within fixed limits. The thermostat is of the Sylphon type. A corrugated metal bellows is filled with sulphur dioxide gas which, by the expansion and contraction caused by changing temperatures, operates the make and break switch.

the average ice box will appreciate the unsanitary character of melting ice. This method of preserving food is a constant menace to health. The damp atmosphere engendered thereby is especially favorable for the breeding of dangerous bacteria. Moreover, the proper temperature in the ice box should range from 38 to 44 deg., and should be dry. Melting ice cannot pro-

FIG. 8,685.—Kelvinator Junior calcium chloride automatic refrigerator unit, ***Specifications,*** 20 cu. ft. capacity size: ***compressor,*** one cylinder reciprocating type, driven by ¼ horse power electric motor, V type belt, no idler; air cooled condenser with forced air circulation; dimensions of unit; length 30¼ ins., width, 17 ins.; height, 24⅝ ins. including legs. If legs be not used, deduct 6⅜ ins. Speed of compressor, 310 *r.p.m.* Normal electric load; approximately 200 watts. Height required for unit under refrigerator (less legs) 23 ins. This allows space to take motor out over guard rail without removing unit.

duce a temperature either low or uniform enough to act as a real preserver of food. On account of these objections, various systems of automatic refrigerating machines of small capacity suitable for home use have been introduced. In some, the refrigerating machine forms a unit with the refrigerator, in others the unit is separate and may be fitted into any household ice

box or placed in the basement with suitable connections passing up through the floor to box.

The various automatic machines are run by a small electric motor which receives its current from the house lighting supply. In operation a predetermined temperature is maintained in the box by a thermostatically operated switch which opens and closes the motor circuit as the temperature within the refrigerator rises and falls within fixed limits.

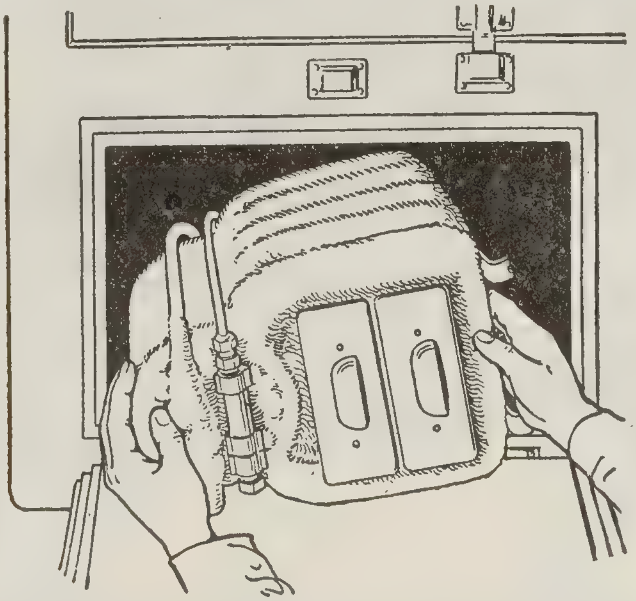


FIG. 8,686.—Frigidaire refrigerating unit, consisting of frost coil and air cooled and compressor unit; it may be installed in any good ice box of standard make with a total capacity not to exceed 8 cu. ft. Specifications: dimensions $26\frac{1}{4} \times 22 \times 59\frac{1}{4}$; ice making, 36 cubes; two trays for making ice cubes or for frozen desserts; compressor unit, single cylinder, slow speed, reciprocating; motor, ¼ horse power, 110 or 220 volts *a.c.* repulsion induction, single phase; *d.c.* 32, 110, 220 volts, compound wound.

NOTE.—***Frigidaire operation.*** The Frigidaire cooling unit, a system of refrigerating coils, is placed in the ice compartment of an ordinary ice refrigerator or display counter and is connected to a motor driven compressor. The unit condenses and evaporates a liquid within the coil and compressor in such a manner as to produce refrigeration. The liquid used is sulphur dioxide and never needs to be replenished. The original supply circulates through the coils regardless of length of service. The temperature is automatically controlled by the temperature in the refrigerator. The electric driven motor starts and stops automatically. A uniform temperature is maintained at all times. Frigidaire is in reality a modern cold storage plant adapted to the needs of the home, meat market, grocery, chain store, delicatessen, hotel, club, hospital, florist shop and other places.

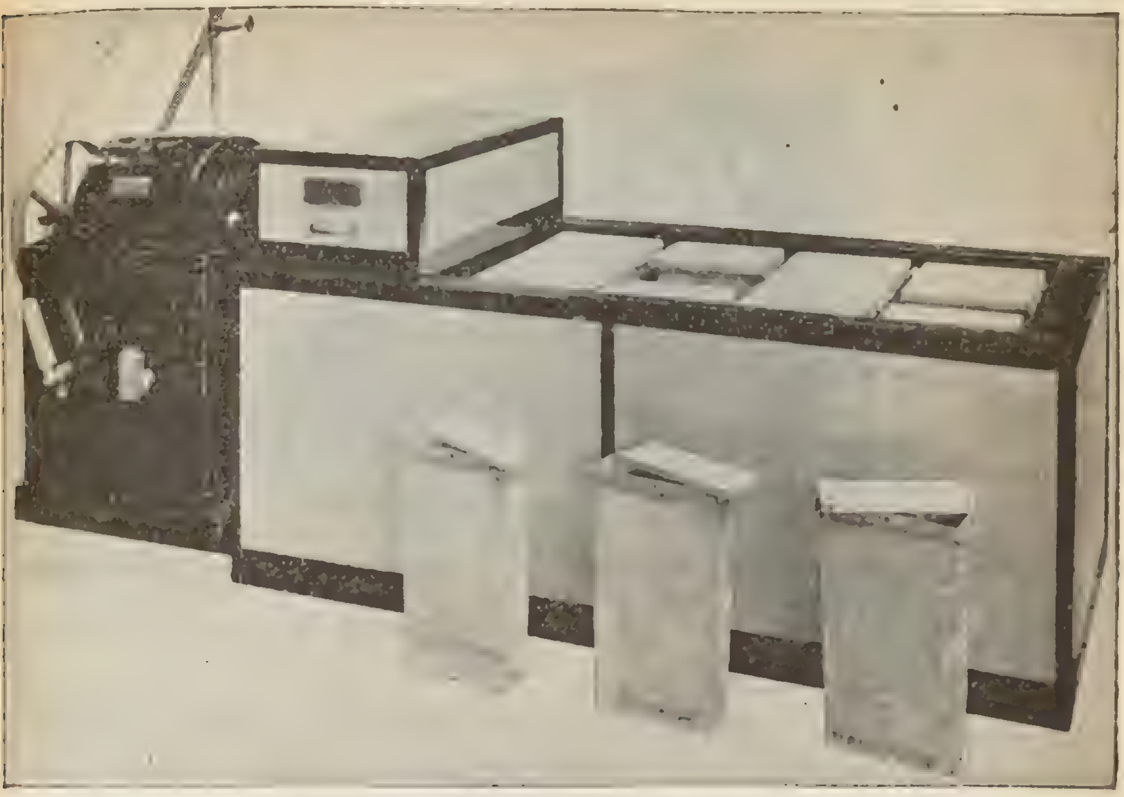


FIG. 8,687.—Audiffren No. 3 Ice Maker; capacity 600 lbs.

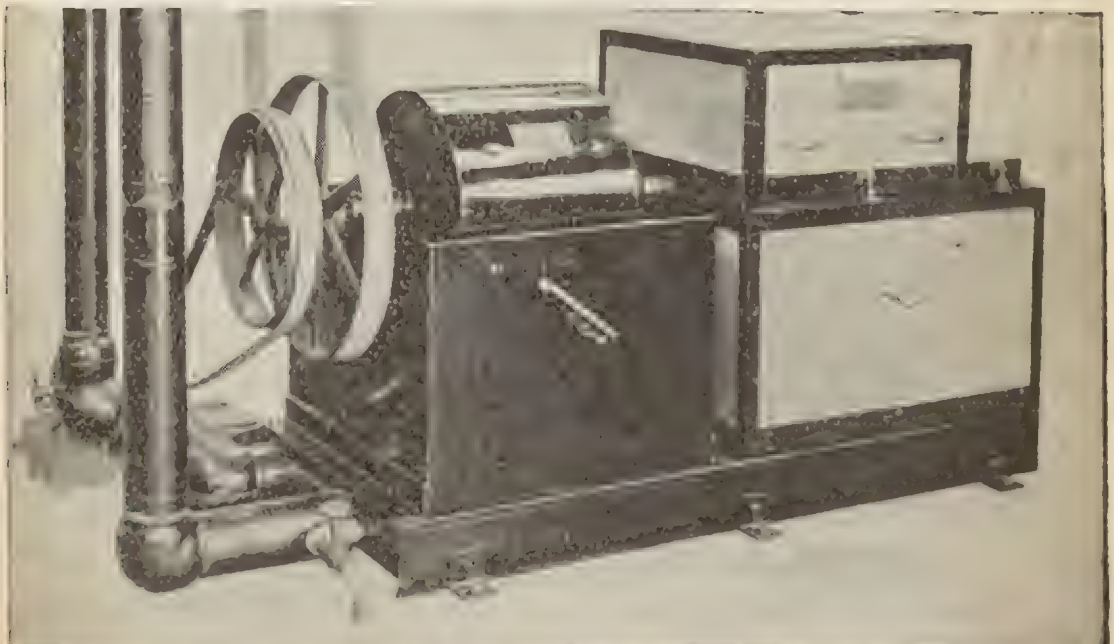


FIG. 8,688.—Audiffren marine refrigerating unit with belt driven pump.

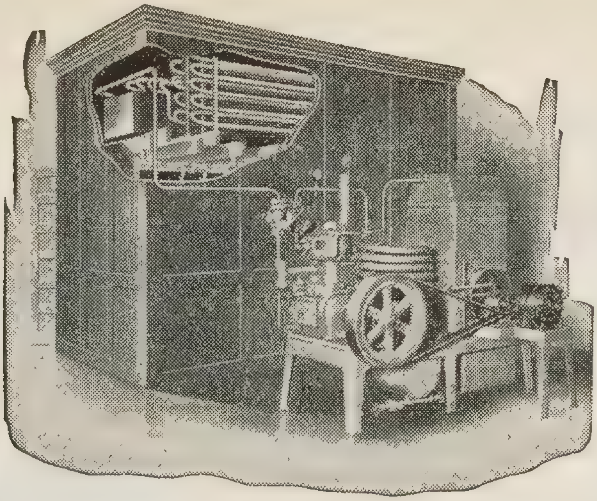


FIG. 8,689.—Fisher self-contained unit connected to the ordinary meat market or delicatessen cooler.

CHAPTER 127

Air Conditioning

Air Conditioning.—By definition the term air conditioning in general may be taken to mean *the treatment to which atmospheric air is subjected in order to regulate its temperature and humidity, and to make it pure.* The manufacturer is no longer under the necessity of selecting for the location of his plant that country or territory which is by nature most frequently supplied with ideal operating conditions.

The effects of air upon comfort and health are due to the reactions of the human being to variations in air temperature, humidity and purity. The sense or feeling of warmth is dependent upon the moisture content of the air, and for this reason comfortable and healthful heating requires coincident regulation of humidity. The purity of the air breathed by the human being is, of course, primarily important to his physical well being and personal efficiency is materially depressed by air that is contaminated with foreign matter, particularly in congested centers, manufacturing districts, or in proximity to any source of pollution. Air conditioning is a sure and sane means of eliminating the personal inefficiencies resulting from improper air qualities in spaces enclosing human beings.

Air is a mechanical mixture, chiefly of the gases, oxygen and nitrogen, about in the proportion of one to four. Air nearly

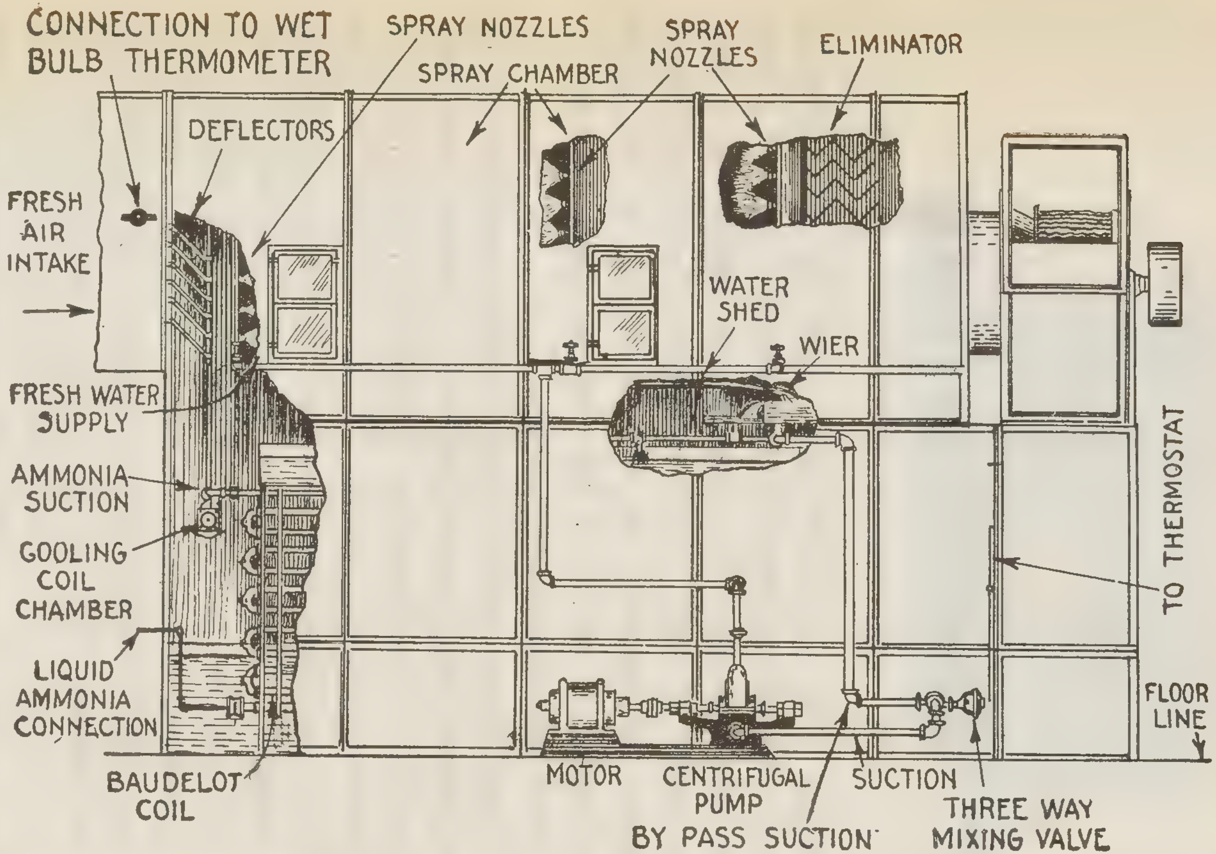


Fig. 8,690.—Sturtevant air conditioning apparatus. The sprayer consists of a spray chamber usually of rectangular cross section, provided with an inlet for the incoming air and with an outlet for the conditioned air. Underneath the spray chamber is provided a tank for catching the excess of spray water above the absorption requirements of the air. The inlet is usually provided with baffles which perform the dual function of distributing the air evenly throughout the cross sectional area and for preventing the spray being carried into the inlet duct. The outlet is provided with a series of eliminators which remove from the air, after it has been treated, all entrained moisture, thereby insuring a practically dry saturated condition of the air. The excess spray water is directed through overflow wiers located in the spray chamber tank, over the series of coils, thus cooled by coming in contact with the cold surfaces, and then collected in a lower tank as iced water. This chilled water is then pumped back into the spray nozzle.

always contains certain impurities, such as ammonia, sulphurous acid and carbon dioxide.

The latter being a product of exhalation from the lungs and of complete combustion, is so universally present (about in the same proportions everywhere, except where concentrated by some local condition), that it may be regarded as a normal constituent of the air.

Heat.—The temperature indicated by an ordinary thermometer is the dry bulb temperature. The scale of an ordinary thermometer, either Fahrenheit or Centigrade, is simply an arbitrary standard by means of which comparisons can be

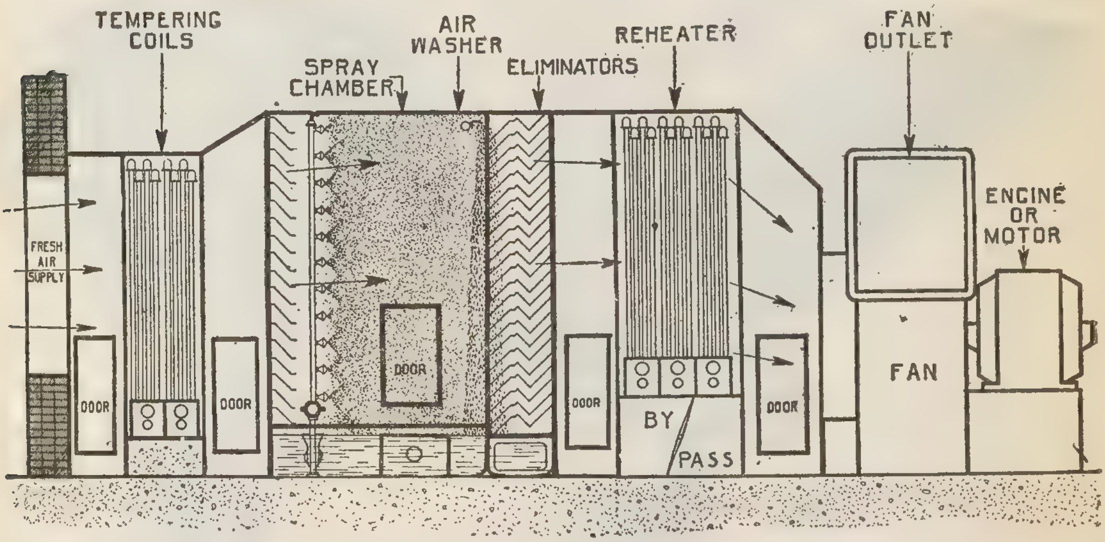
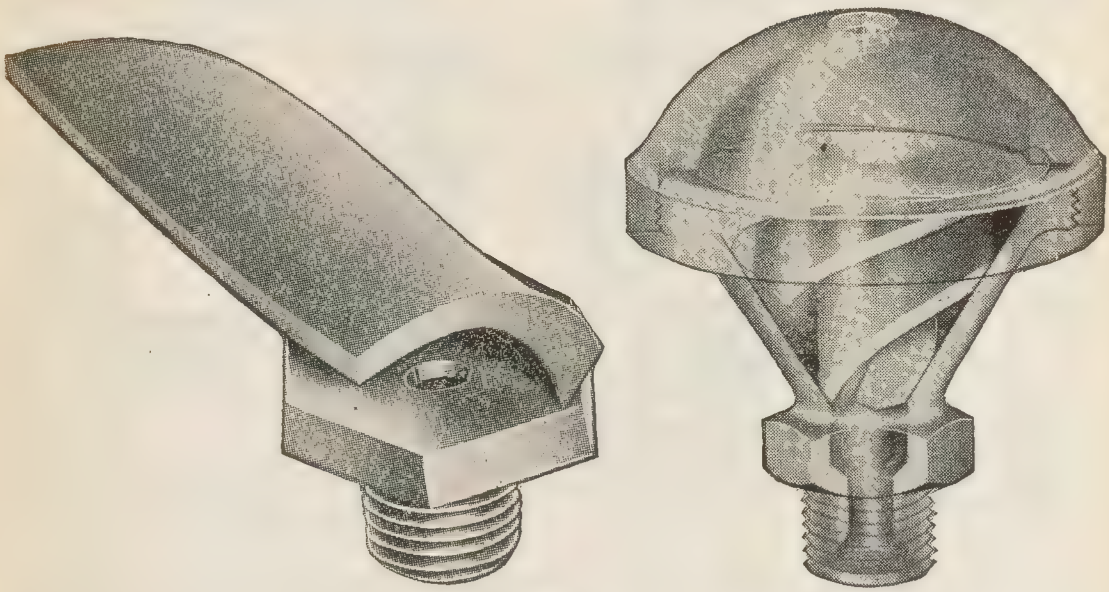


Fig. 8,691.—Section through Sturtevant air conditioning system.

established. The dry bulb temperature measures the degree, or intensity, of the heat, or, it may be said, the dry bulb temperature measures the degree of effort which the heat will exert to move from one position to another.

A non-hygroscopic material is one which neither absorbs nor gives off moisture and hence is not affected by the humidity of the air. Such a material if surrounded by air, say at 90° F., will take up heat from the air until both have reached the same temperature. At the beginning of the heat transfer, the *rate of flow* of heat from the air to the material will be greater than

at any other time, because the temperature difference, or temperature head (90°−60°=30°) is greater at that time, constantly decreasing as the air and the material approach the same temperature. The rate of heat transfer is thus proportional to the temperature difference between the two. Thus, if it be desired to heat a certain material as quickly as possible, the dry bulb temperature of the air surrounding the material must be raised as many degrees as practicable above the de-



FIGS. 8,692 and 8,693.—Sturtevant spray nozzles. Fig. 8,692, rain spray nozzle; fig. 8,693 phantom view of atomizing nozzle, under a pressure of 19 lbs. per sq. in. the atomizer nozzle will deliver 1½ gals. per minute.

sired temperature of the material, so that the rate of heat flow from the air to the material will be as rapid as possible.

In the case of an hygroscopic material, that is, one which will absorb moisture, the dry bulb temperature does not indicate the heating capacity of the air, nor does it even indicate the rate at which the heating effect of the air will be consummated. This is true because hygroscopic materials are

affected as much by the moisture present in the air as by the heat. Thus, an hygroscopic material may absorb moisture so rapidly that, due to the latent heat so regained, it may become hotter than the dry bulb temperature of the air itself, and actually give off heat to the air.

Air conditioning is principally concerned with hygroscopic materials and here the dry bulb temperature alone is of rela-

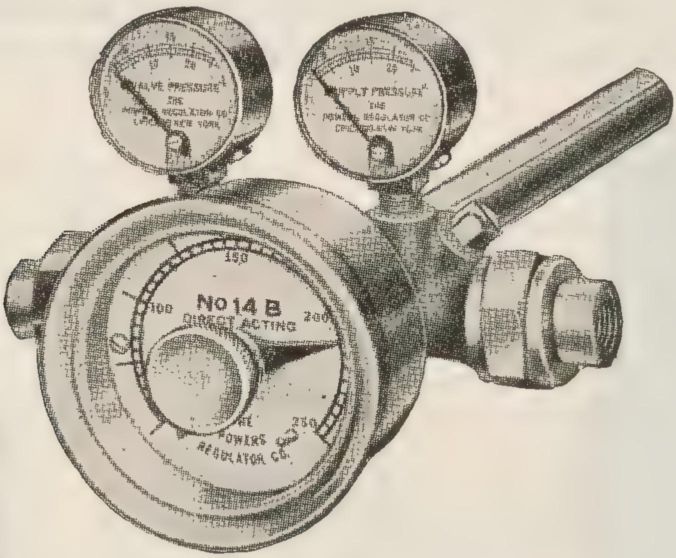


Fig. 8,694.—Sturtevant regulator.

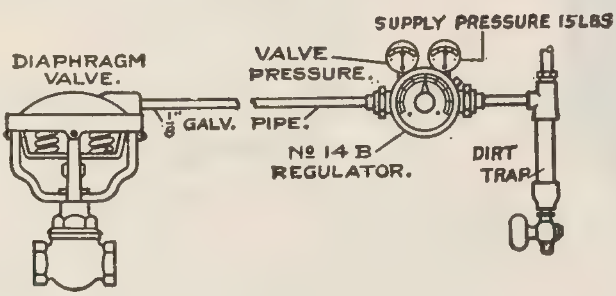


Fig. 8,695.—Assembly of Sturtevant regulator and valves.

tively small importance because the factor of moisture must be carefully considered.

Humidity.—Air is capable of holding, as a mechanical mixture with itself, varying quantities of water vapor, depending

upon its temperature. When there is mixed with the air all of the water vapor which it can hold, the air is said to be *saturated*. Air which is not fully saturated will readily absorb water vapor when in the presence of water, the water, as it is evaporated, being converted from a liquid to a vapor.

On the other hand, if partly saturated air be reduced in temperature, until the amount of moisture present corresponds to the amount which the air is capable of holding at the given temperature, it will, obviously, become *saturated air*.

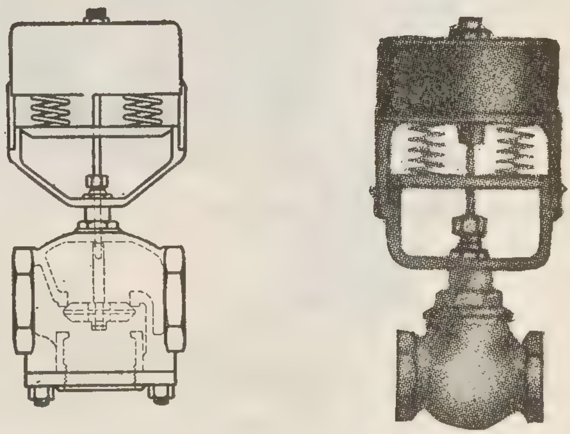


FIG. 8,696.—Sturtevant thermostat.
FIGS. 8,697 and 8,698.—Sturtevant low pressure all metal valve.

If the temperature of the air be further reduced, its ability to hold moisture being reduced accordingly, the excess moisture will be condensed, which means that it will be converted from a vapor to a liquid, the reverse of the process which occurred as the air absorbed the moisture. The process of converting liquid water into water vapor requires a great quantity of heat.

This heat is used only in performing the conversion, the temperature of the liquid and the vapor being the same at the end of the process. If the conversion be from liquid to vapor, this involves the latent heat of evaporation; if from vapor to liquid, of the latent heat of condensation.

Thus, when air absorbs moisture, that is, when it is humidified, the latent heat of evaporation must be supplied either from the air or otherwise. And conversely, when the moisture from the air is condensed, the latent heat of condensation, equivalent to the latent heat of evaporation, is recovered.

***Air.**—Cold air is saturated when it contains very small quantities of water vapor, whereas warm air is not saturated until it contains much larger quantities of vapor.*

For instance air at zero is saturated when it contains but one half of one grain (1/7000th lb.) of water vapor per cu. ft. Air at 70° is saturated when it contains 8 grains of vapor per cu. ft., while at 83°, 12 grains per cu. ft. are required to saturate.

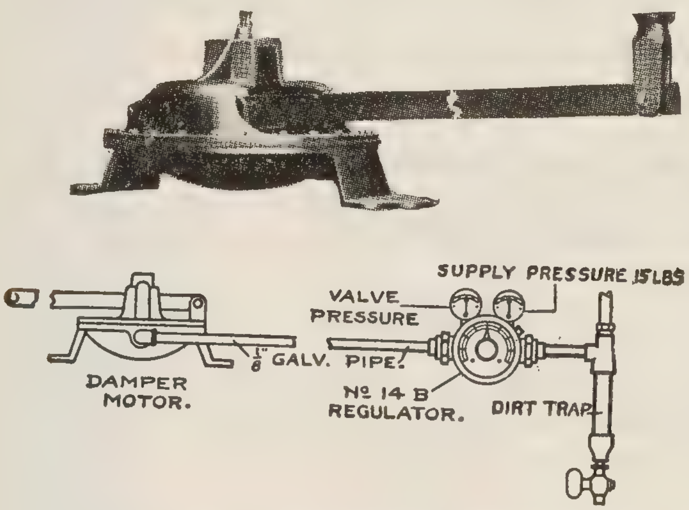
Example.—Air at 83° is saturated when it contains 12 grains of water vapor per cu. ft. Assume that it contain 8 grains per cu. ft. Its absolute humidity is, then 8 grains per cu. ft.; its relative humidity 66⅔%. Such air will exert a greater moistening effect than air at 92° containing the same 8 grains of vapor per cu. ft.

Absolute Humidity.—The quantity of water vapor actually present in a given volume of air, without regard to its temperature, is called its absolute humidity. Thus if air, at any temperature, contain 4 grains of water vapor per cubic foot, its absolute humidity is expressed as 4 grains per cubic foot.

Relative Humidity.—Since air may contain varying quantities of water vapor at the same temperature, it is necessary to express its degree of saturation as related to its temperature. Thus, there has been established the term relative

humidity. Relative humidity is an expression, in percentage, of the degree of saturation of air at any given temperature. A relative humidity of 50% means that the air, at its given temperature, contains 50% of the water vapor required to saturate it at that temperature.

Example, 70° air is saturated when it contains 8 grains of vapor per cubic foot. Assume that it contains 4 grains per cubic foot. Its absolute humidity is 4 grains per cubic foot. Its relative humidity is 50% since 4 is 50% of 8. Similarly, if the same air were heated to 83° its absolute humidity would still be 4 grains per cu. ft., but its relative humidity would be



Figs. 8,699 and 8,700.—Sturtevant rubber damper diaphragm motor and assembly of motor and regulator.

but 33⅓%, because 12 grains of vapor per cu. ft. required to saturate air at 83°. $\left(\frac{4\times100}{12}=33\tfrac{1}{3}\%\right)$.

Obviously, therefore, the relative humidity depends equally upon both the factors of temperature and moisture content. A variation in either alters the relative humidity. A clear conception of the relation between temperature and moisture content is essential to an appreciation of air conditioning and the effects of air upon the materials it surrounds, because it is the relative humidity, (not the absolute humidity) which determines the effects of air upon such materials. The relative humidity is the governing factor because the drying or moistening effect of air depends upon

the relation between the vapor pressure of the moisture in the material exposed to the air and the vapor pressure of the moisture mixed with the air itself. The vapor pressure of the moisture mixed with the air is proportional to the relative humidity of the air. Since this relation is true, calculations are usually based upon relative humidity rather than upon relative vapor pressure, although the latter might be considered the more direct relation.

Moistening Effect of Air.—*Air at high relative humidities (regardless of the absolute humidity) exerts a greater moistening effect than air at lower relative humidities.*

The moistening effect of the air varies approximately with its relative humidity, without regard to the actual weight of water vapor present.

In a textile mill, for instance, where one of the chief functions of air conditioning is to control the moisture in the yarns in course of manufacture, it should now be obvious that temperature control is equally as important as moisture control, since it is upon the relative humidity (water vapor content as related to temperature) that the moistening effect of the air depends.

Drying Effect of Air.—Briefly, *the drying effect of air varies approximately inversely with its relative humidity, the greater the relative humidity, the lesser the drying effect.*

It should be noted that it is the relative humidity which determines the effect and that, therefore, the effect depends upon both the temperature and the water vapor content of the air—since relative humidity depends upon both these factors.

Heating Effects of Air.—The quantity of heat which dry air contains is very small, because its specific heat is low, .2415 (for ordinary purposes) which means that one lb. of air falling one degree of temperature (Fahr.) will yield but .2415 of the heat which would be available from one lb. of water, reduced 1° in temperature. The presence of water vapor in the

air materially increases the total heating capacity of the air because of the latent heat of the vapor itself.

Moist hygroscopic materials in the presence of dry air, even at high dry bulb temperatures, may actually be cooled, rather than heated. This occurs because the dry air immediately begins to evaporate moisture from

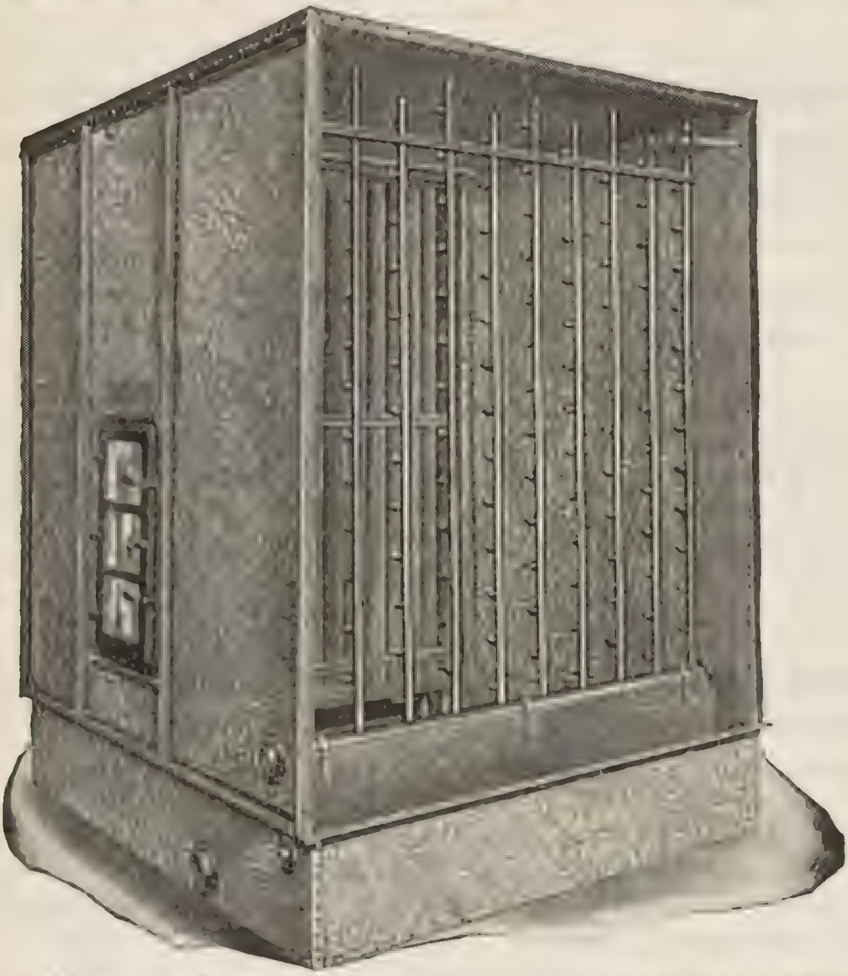
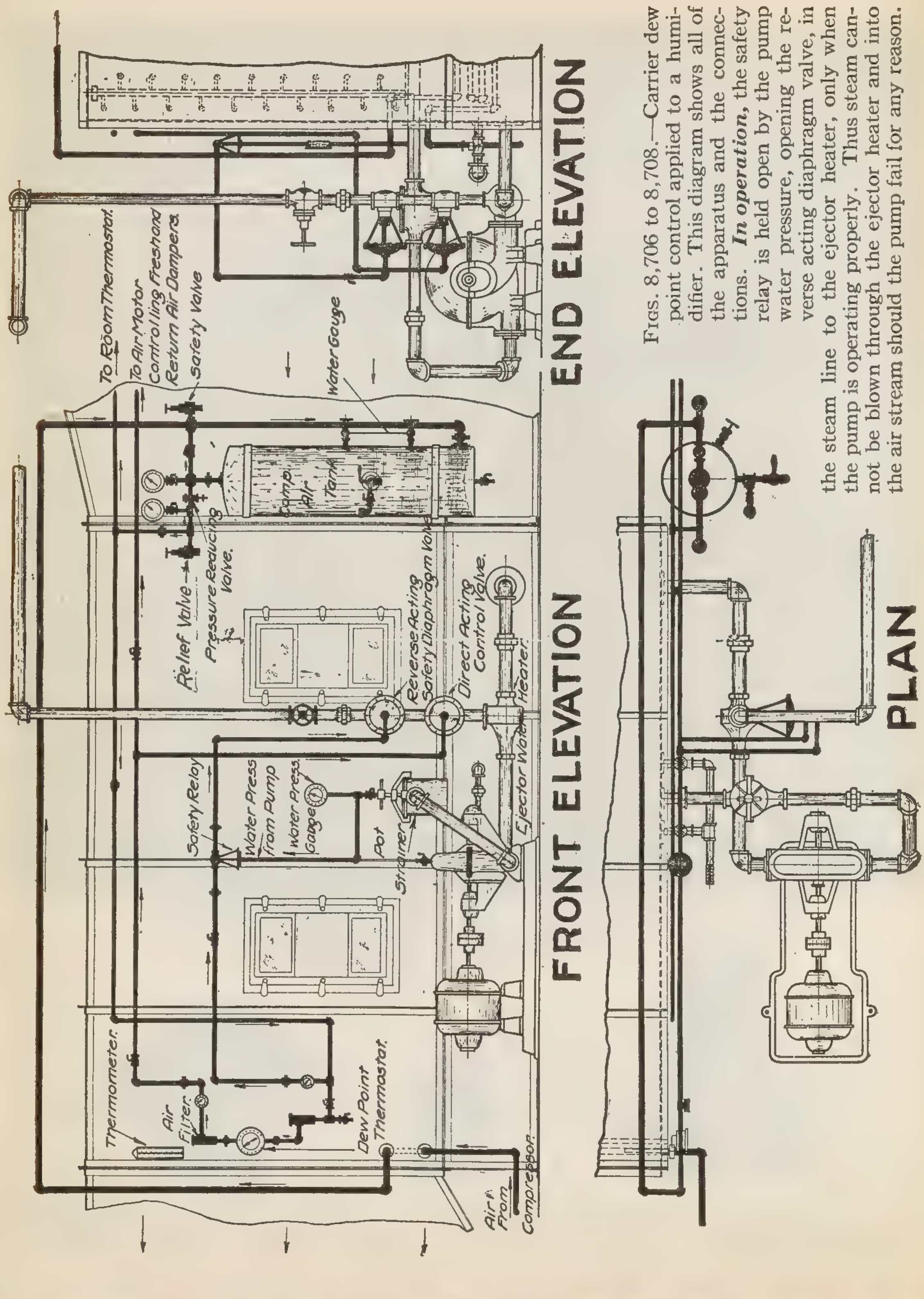


FIG. 8,701.—Webster type G. W. apparatus. ***The nozzles*** are arranged uniformly over the entire spray chamber, there being but one group on this type of apparatus, the quantity of water handled being sufficient to remove foreign matter contained in the entering air, and capable of cooling this air 70% of the wet bulb depression. In the apparatus the spray chamber piping consists of two banks of sprays, one discharging the water in the direction of the air flow, the other discharging against the air flow.

the material, and in so doing removes from the material, as well as from the air, the latent heat of evaporation.

Wet Bulb Temperature.—This is the temperature of

Figs. 8,702 to 8,705.—Webster spiral mist nozzle in operation and disassembled to show construction.



FIGS. 8,706 to 8,708.—Carrier dew point control applied to a humidifier. This diagram shows all of the apparatus and the connections. ***In operation,*** the safety relay is held open by the pump water pressure, opening the reverse acting diaphragm valve, in the steam line to the ejector heater, only when the pump is operating properly. Thus steam cannot be blown through the ejector heater and into the air stream should the pump fail for any reason.

evaporation, or better, *the temperature at which the air would become saturated if moisture were added to it without the addition or subtraction of heat.* The wet bulb temperature, in conjunction with the dry bulb temperature is an exact measure of the humidity of the air, and it is also an exact measure of the heat content of the air.

In air conditioning the dry bulb temperature and the wet bulb temperature must both be controlled if the effects of air are to be regulated.

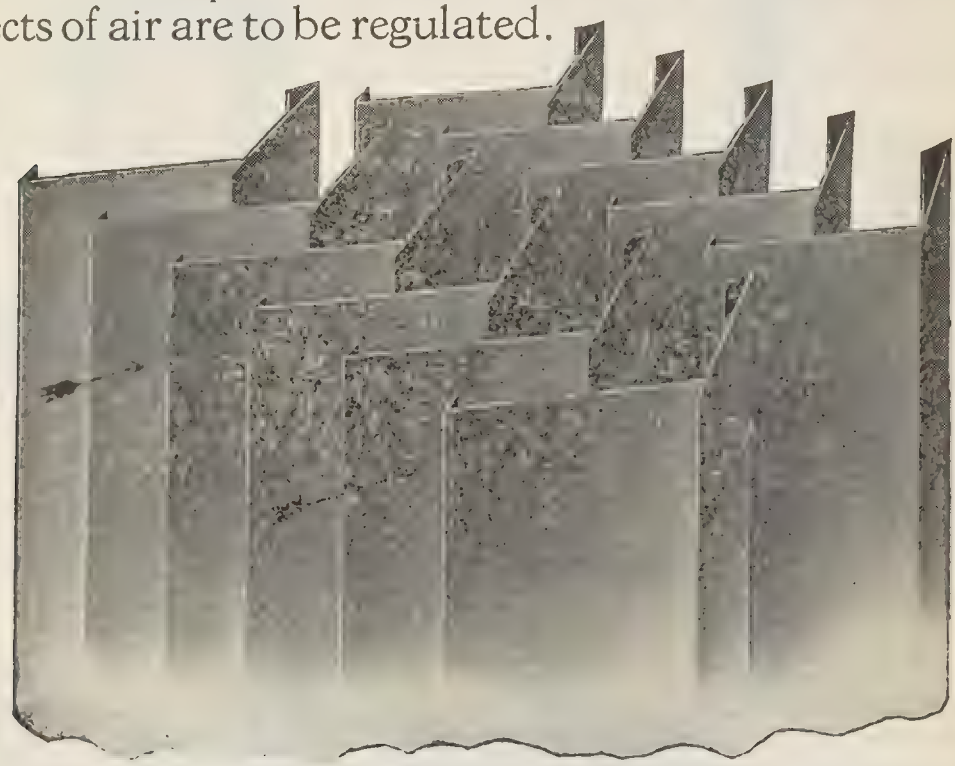


Fig. 8,709.—Webster Eliminator for separating the free moisture from the air after it has been subjected to the sprays, a series of vertical baffles are provided and may be constructed of galvanized steel, ingot iron or copper as desired. The front and rear sections of the eliminator are staggered so that the air streams will be split in passing through the same. The construction of the eliminator is such that all entrained moisture is removed from the air, being discharged to generator or transformer. The usual velocity through either type of apparatus is 500 ft. per minute, resulting in a resistance of .25 in. water gauge.

The Dew Point.—The temperature of saturation is called the dew point because it is *the temperature at which moisture begins to condense, in the form of tiny droplets, or dew.*

Methods of Air Conditioning.—There are several methods

employed for the automatic control of temperature and humidity and various standard forms of apparatus are used for accomplishing the required purposes. The Carrier dew point control is here given as an illustration.

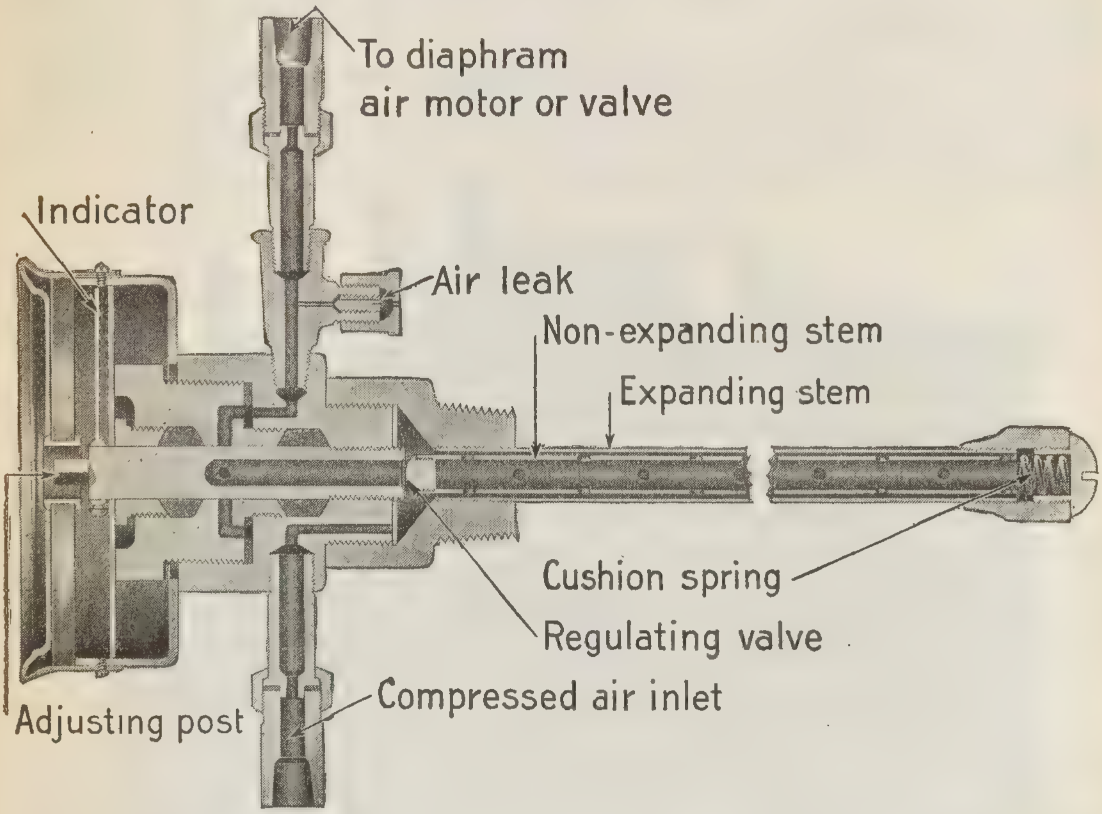


FIG. 8,710.—Carrier graduated thermostat; sectional view showing operating principle. ***It consists essentially of*** an outer expanding stem, usually of brass, and an inner non-expanding stem of nickel steel. These two members are rigidly connected at one end. The other end of the inner, non-expanding member, is provided with a bronze valve, ground to fit an adjustable valve seat. Between the inner and outer tubes there is an annular chamber. Compressed air, from a small auxiliary compressor, usually driven from the fan or pump shaft, is admitted to this annular space, and its passage through the instrument is regulated by the small valve attached to the non-expanding stem. As the temperature of the air surrounding the stem of the instrument rises, the outer member expands, the regulating valve recedes from its seat, and the compressed air passes through into the outlet chamber, from whence it goes to the diaphragm valve in the steam line to the spray water heater. Upon reaching this diaphragm valve, the compressed air moves it so as to decrease the amount of steam admitted to the ejector heater and thereby reduce the temperature of the spray water as required. When the temperature of the air leaving the conditioning machine falls below the point desired, the outer shell contracts and closes the compressed air supply to the diaphragm valve, whereupon the pressure upon the diaphragm of the valve is relieved through the air leak, as shown in the figure, and the valve opens, admitting steam to the spray water heater.

With this control, the dew point, or saturation temperature of the air is automatically controlled by means of a simple expansion thermostat, exposed to the air at the instant of saturation in the air conditioning machine itself. Thus, the absolute humidity of the air is definitely fixed in the conditioning machine, because, as has been pointed out, where air is saturated at a given temperature, it contains a given quantity of water vapor corresponding to that temperature. Obviously, any absolute humidity (*i. e.*, the number of grains of water vapor per cu. ft. of air) can be established by adjusting the thermostat to the corresponding temperature.

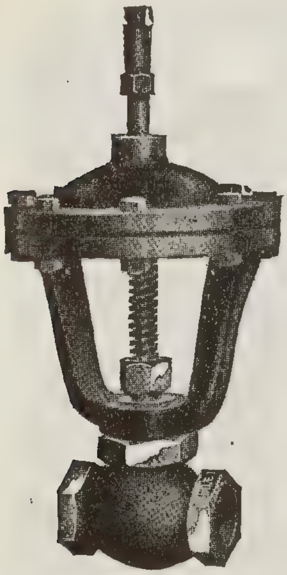


FIG. 8,711. — Carrier diaphragm valve. ***It is located*** in the steam line to the water heater, and is of the direct acting type, which means that it is held open by means of a spring, and closed when air pressure is admitted to its diaphragm motor.

The saturated air leaving the machine is heated by passage through suitable heaters, and its dry bulb temperature is increased sufficiently to establish the required dry bulb temperature in the space being conditioned.

The temperature of the air leaving the heaters is controlled by means of a second thermostat located in the room itself, and regulating the steam admitted to the heaters.

In certain instances it is permissible, during the summer season, for the dry bulb

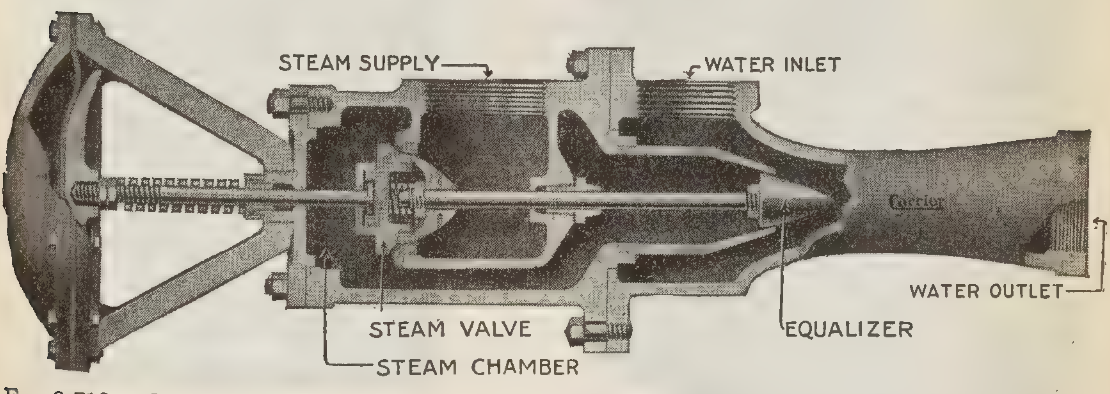
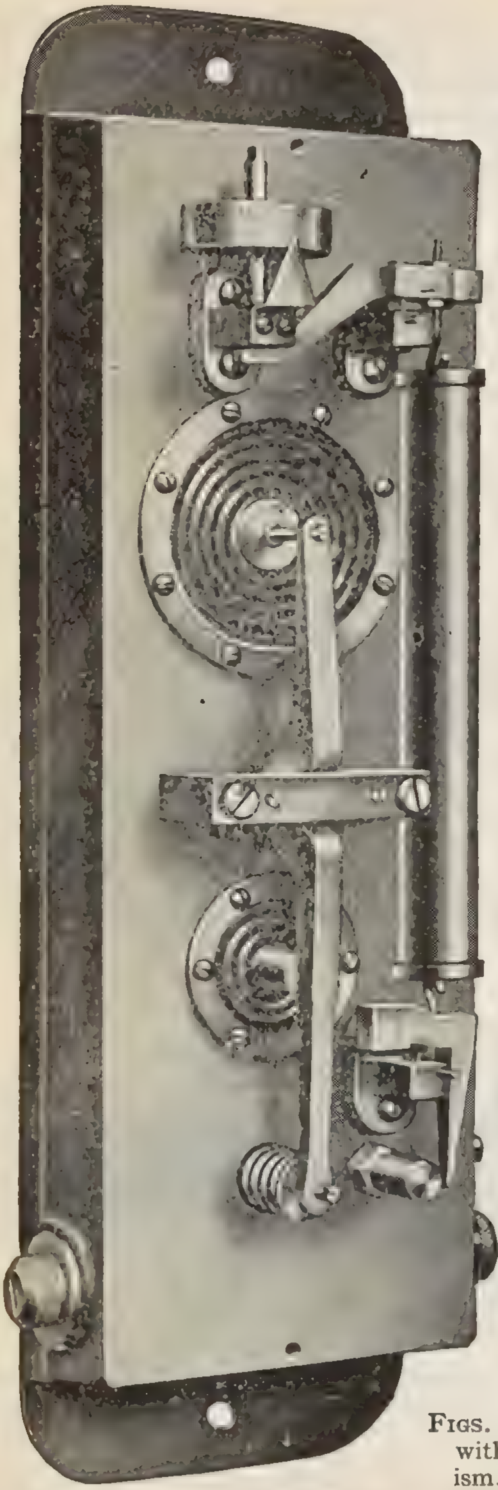
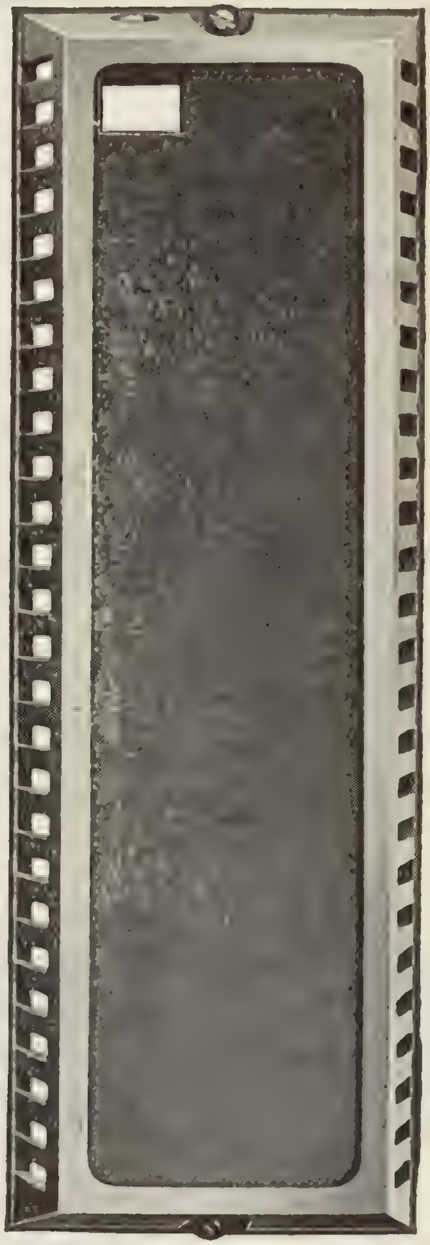


FIG. 8,712.—Carrier ejector heater. It is used when steam is available at a pressure of 3 lbs. or more. This heater is installed in the suction line of the pump and heats the water by direct ejection of the steam into the water. Steam enters through the steam supply, and is admitted through a diaphragm operated steam valve, into the steam chamber, and then through the equalizing orifice into the water stream. The opening at the equalizer varies in accordance with the opening of the steam valve for all positions of the latter.





FIGS. 8,713 and 8,714.—Carrier adjustable hygrostat with cover removed to show the hygroscopic mechanism. This instrument varies the humidity in accordance with variations in temperature, maintaining any desired relation between the two.

temperature to exceed that maintained in the winter, so long as the relative humidity is controlled at an approximately constant value. In such instances there is no provision for dehumidification, and the humidifier is used to effect as great a degree of cooling as possible by evaporation only. The dew point temperature of the air leaving the humidifier then becomes the same as the wet bulb temperature of the outdoor air, the dew point thermostat being inoperative. The dry bulb temperature in the enclosure is regulated in accordance with the prevailing wet bulb temperature of the entering air and this regulation is accomplished by means of a hygrostat located within the enclosure, usually adjacent to the thermostat which is used for winter control. The shift from the room thermostat to the room hygrostat can be made either manual or automatic as required. In most cases it is automatic.

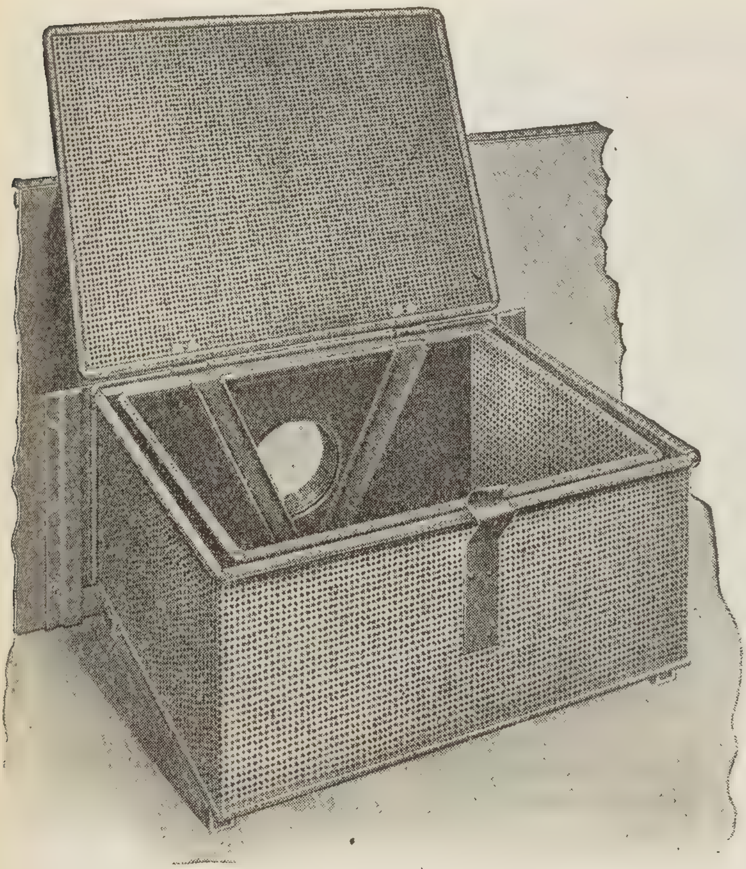


FIG. 8,715.—Webster double box brass strainer with hinged lid and a removable inner basket having a free area 15 times that of the pump suction. The entire strainer is removable for cleansing and inspection. For concrete tanks, the strainer is of the cylindrical type having the same free area through the inner basket.

The hygrostat, which is sensitive to relative humidity, controls the dry bulb temperature of the enclosure by regulating the volume of air admitted. This avoids the use of heaters, and takes advantage of the available sun heat, or heat from sources within the room. If the dry bulb temperature of the enclosure be high, the hygrostat opens the volume dampers and admits a greater volume of cooler air from the humidifier.

If the dry bulb temperature be low, the hygrostat reduces the volume

of cooler air and permits the sun's heat, or the heat from sources within the enclosure, to restore the desired condition.

If in summer, a dry bulb temperature lower than that of the atmosphere must be maintained, a dehumidifier is provided. In this case the dehumidifier acts, during the winter, as a humidifier, under dew point control, and, during the summer, functions as a dehumidifier under the same dew point control, except that the dew point thermostat at the dehumidifier, instead of regulating the steam to the water heater, regulates the three way mixing valve in the pump suction line, controlling the temperature of the spray

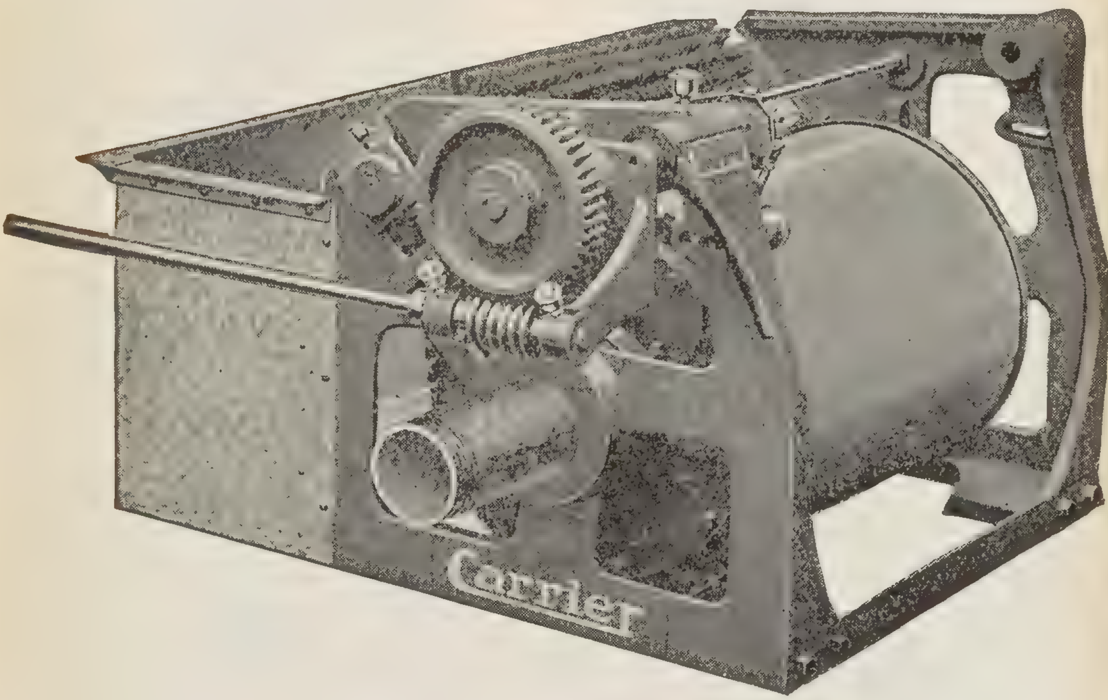


FIG. 8,716.—Carrier rotary strainer for removal of dirt or other foreign matter. The strainer is placed in the settling tank of the conditioning machine. The suction line to the pump is connected to a hollow trunnion, open to the interior of the revolving screen cylinder. A stiff cylindrical brush revolves against the surface of the revolving screen, sweeping it clear of accumulated dirt or fibrous matter. The dirt so collected by the brush is deposited in a small auxiliary tank, so that it does not again mingle with the water. The strainer tank requires cleaning about once a week, ordinarily, the operation consuming not more than 15 minutes.

water by admixture of the warmer water from the spray chamber settling tank and cold water from the refrigerating coils, or other source; and the room thermostat, instead of regulating the steam to the heaters, regulates the volume dampers in the supply ducts, controlling the temperature of the

room by means of the volume of cold, dehumidified air permitted to enter. The two control instruments, then, regulate the actual water vapor content of the air and its dry bulb temperature, thereby fixing its relative humidity.

There are many variations of this control, but to a general understanding of air conditioning practice, a knowledge of this control is sufficient.

In the complete conditioning of air, its purity must be maintained. Air conditioning machines, humidifiers and de-

FIG. 8,717.—Carrier fixed suction strainer, the cover open. The pump connection shows in the lower left corner.

humidifiers, thoroughly wash and cleanse the air, removing practically all of the solid or soluble gas impurities, and most of the aerobic organisms of disease and decay.

The cleansing effect of the Carrier air conditioning machine is produced by the finely divided and uniformly dense water spray and the staggered washer eliminator plates against which the air is baffled as it leaves the chamber. These plates are flooded with water, so that their wet surfaces accomplish an extremely effective cleansing action.

Addition of Moisture to Air.—The addition of moisture to the air is termed *humidification*, and the conditioning machine, when functioning to add moisture to the air, is termed a *humidifier*. A humidifier is, in reality, *a low pressure, low temperature boiler in which the water is evaporated into vapor and then caused to mix with the air.*

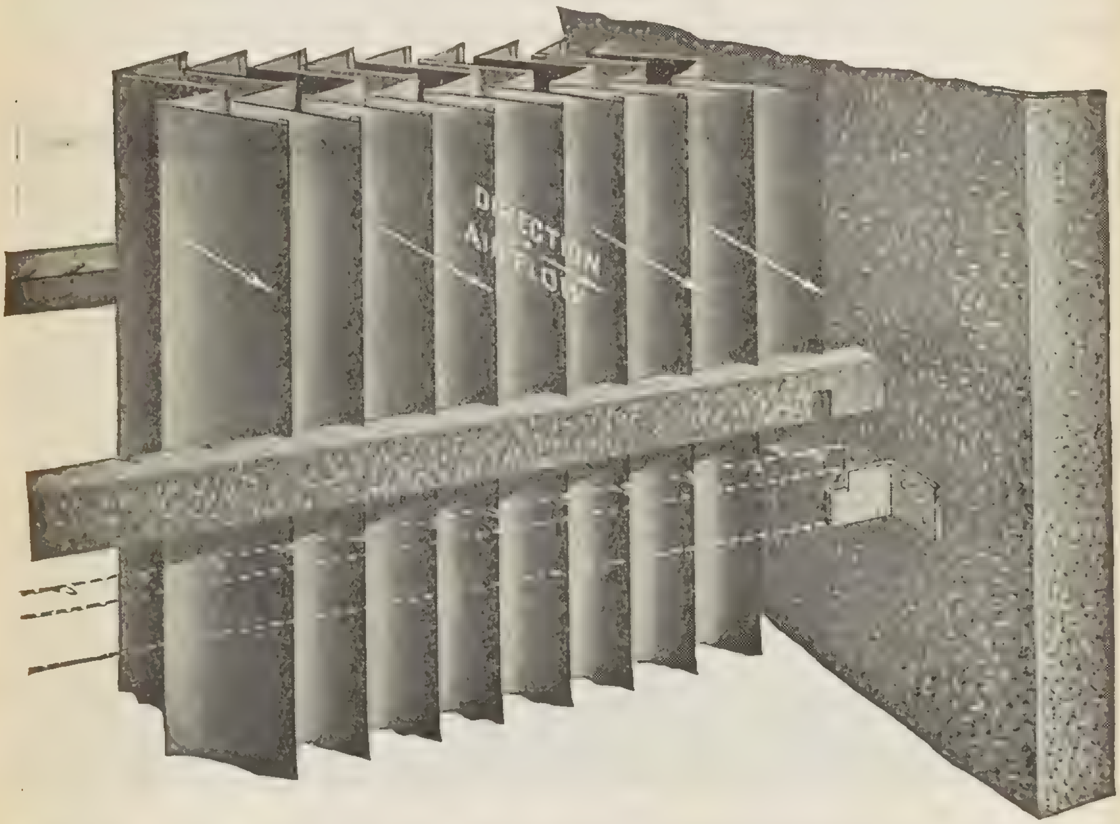


FIG. 8,718.—Carrier washer elimination plates. ***In operation,*** as the air leaves the spray chamber it passes through a set of staggered washer eliminator plates which baffle the air from right to left, so that it is scrubbed against the wet surfaces of the plates. The cleansing action resulting is extremely effective, removing practically all of the solid foreign matter carried in the air, including those air borne organisms of disease, mold or decay with which the air may be contaminated. The latter three corrugations of the plates are provided with lips or gutters which trap the entrained free water carried in the air stream, remove it and return it to the settling tank.

In a humidifier, the water acts as the medium which conveys heat to the air, and as the source of the water vapor required to saturate the heated air. When the temperature of the spray water is above that at which the moisture in the air will condense, the conditioning machine is functioning as a humidifier.

Removal of Moisture from Air.—When the conditioning machine is functioning to remove moisture from the air, it is called a *dehumidifier*, and the process of removing moisture from the air is termed *dehumidification*.

The removal of moisture from the air is accomplished by condensation, the temperature of the air being lowered below its dew point, thereby causing the excess water to condense and fall into the tank of the conditioning machine. In this

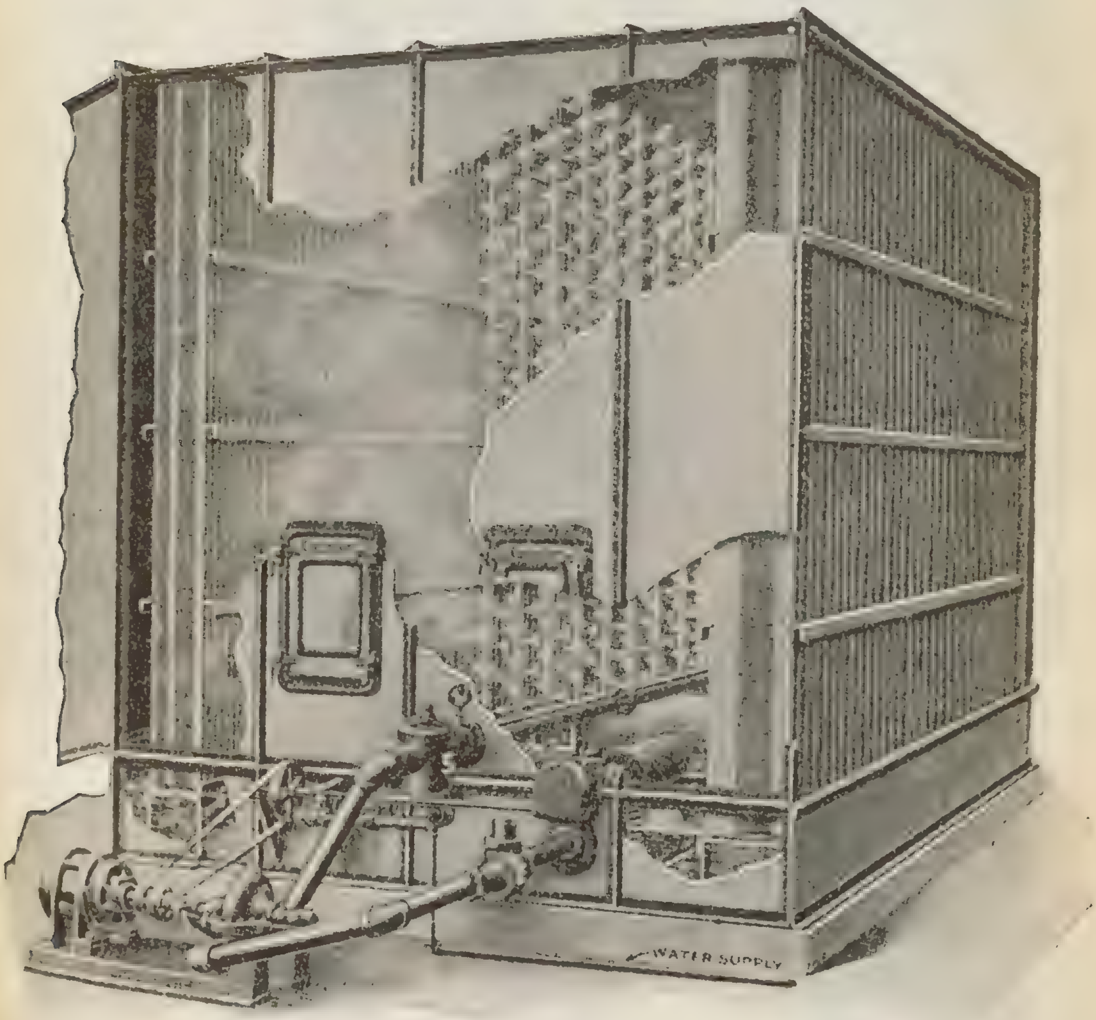


FIG. 8,719.—Carrier humidifier equipped with rotary strainer. ***In operation,*** air enters at right, through the baffle plates, passes through the spray chamber and leaves at the left through the washer eliminator plates. ***The parts are,*** R, rotary strainer; E, ejector heater P, pump; M, pump motor; S, pot strainer.

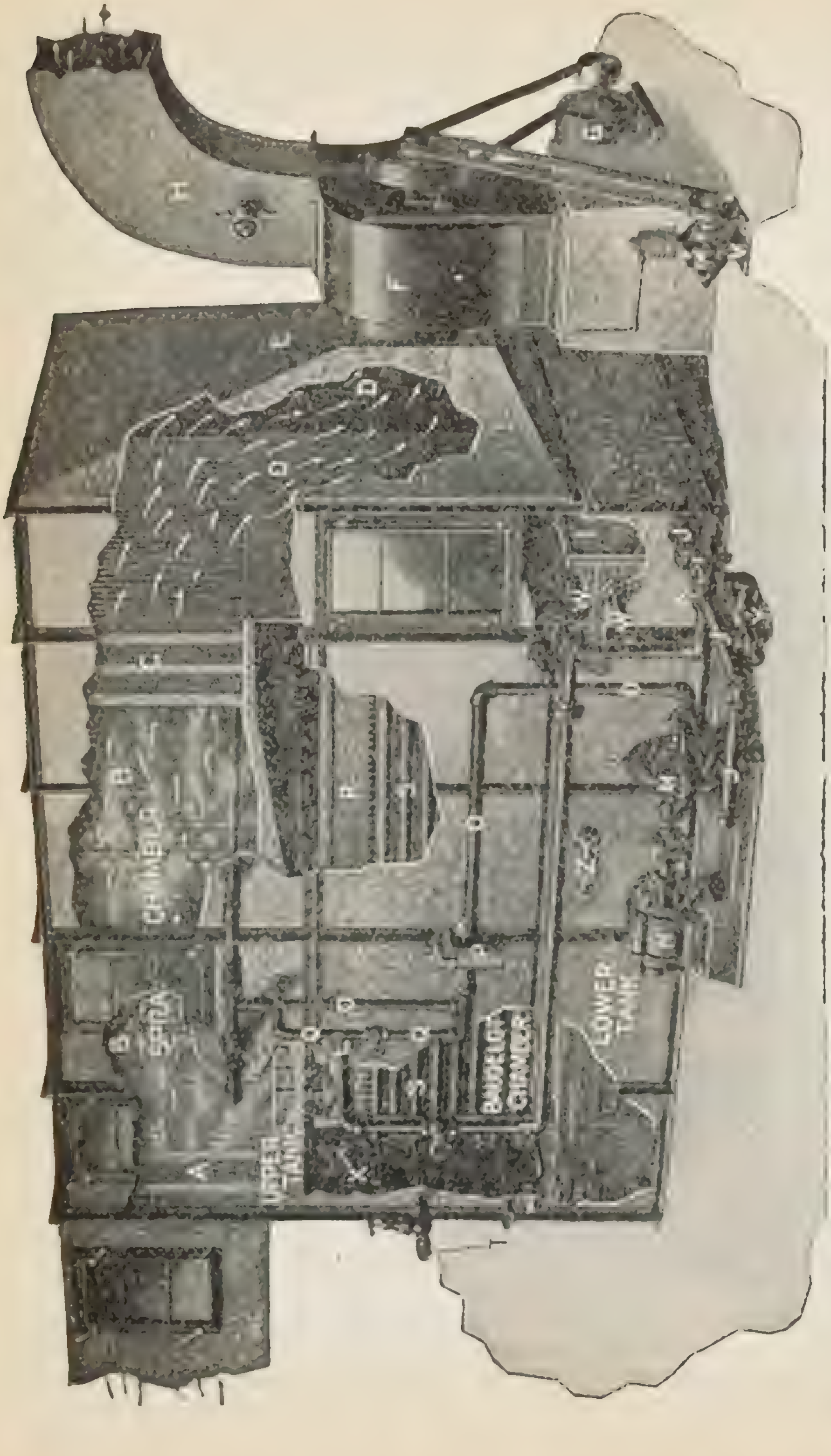


Fig. 8,720.—Carrier dehumidifier. A, distributor plates; B, sprays; C, eliminator plates; D, outlet; E, fan connection; F, fan; G, fan motor; H, fan outlet connection to duct system; I, pump suction screen; J, pump suction line; K, three-way mixing valve; L, line from upper tank to three-way valve; M, pump; N, pump motor; O, pump; discharge line; P, pot strainer; Q, by-pass to upper tank for quick cooling at start; R, drip troughs over baudelot coils; S, baudelot cooling coils; T, refrigerant connections; V, air comprsseor for automatic control; W, overflow from lower tank; X, upper tank drain; Y, lower tank drain to sewer; Z, fresh water connections for make up and cleaning.

case the water acts solely as a conveyor of heat from the air (beside its cleansing action) and, as such, the finely divided mist is extraordinarily effective (practically 100%).

In the Carrier system the dehumidifier functions either as a humidifier or as a dehumidifier, without alteration or rearrangement, except that the valves in the control line from the dew point thermostat are adjusted to connect the steam control to the water heater for winter operation, and to connect the three way mixing valve for summer operation.

Whether the requirement is humidification or dehumidification, the apparatus always operates under accurate automatic control, maintaining

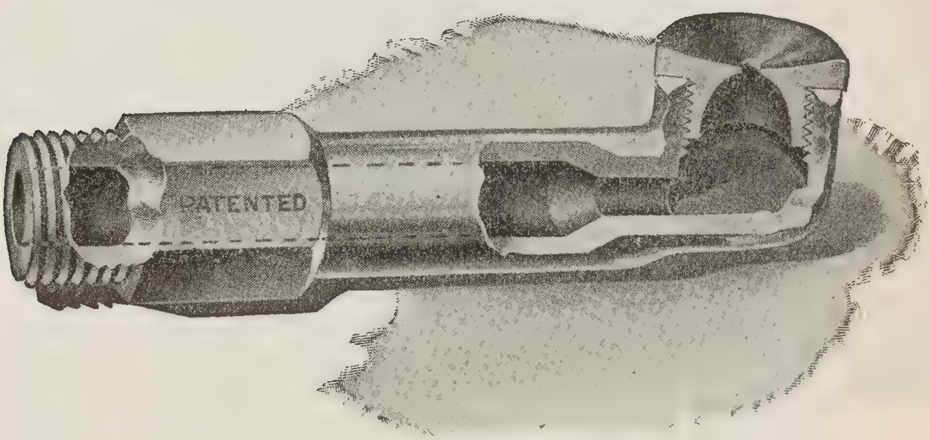


Fig. 8,721.—Carrier Spray nozzle. The water entering through the small circular chamber tangentially, acquires a whirling motion and is discharged through a small orifice in the center of the cap. The approach to the orifice is conical in shape, so that the rotation, or whirling speed of the water is greatly increased at the instant of discharge.

the required indoor conditions winter and summer, regardless of the outdoor weather.

Air Movement.—The effectiveness of any air conditioning apparatus depends as much upon the proper distribution of the air as upon the efficiency of the conditioning machine itself. It may be said that an air conditioning installation is no better than its duct system. To be effective, the conditioned air must be uniformly distributed over the entire area of the enclosure, and, especially in closed or dry rooms

processing rooms, the circulation must not only be uniform, but vigorous.

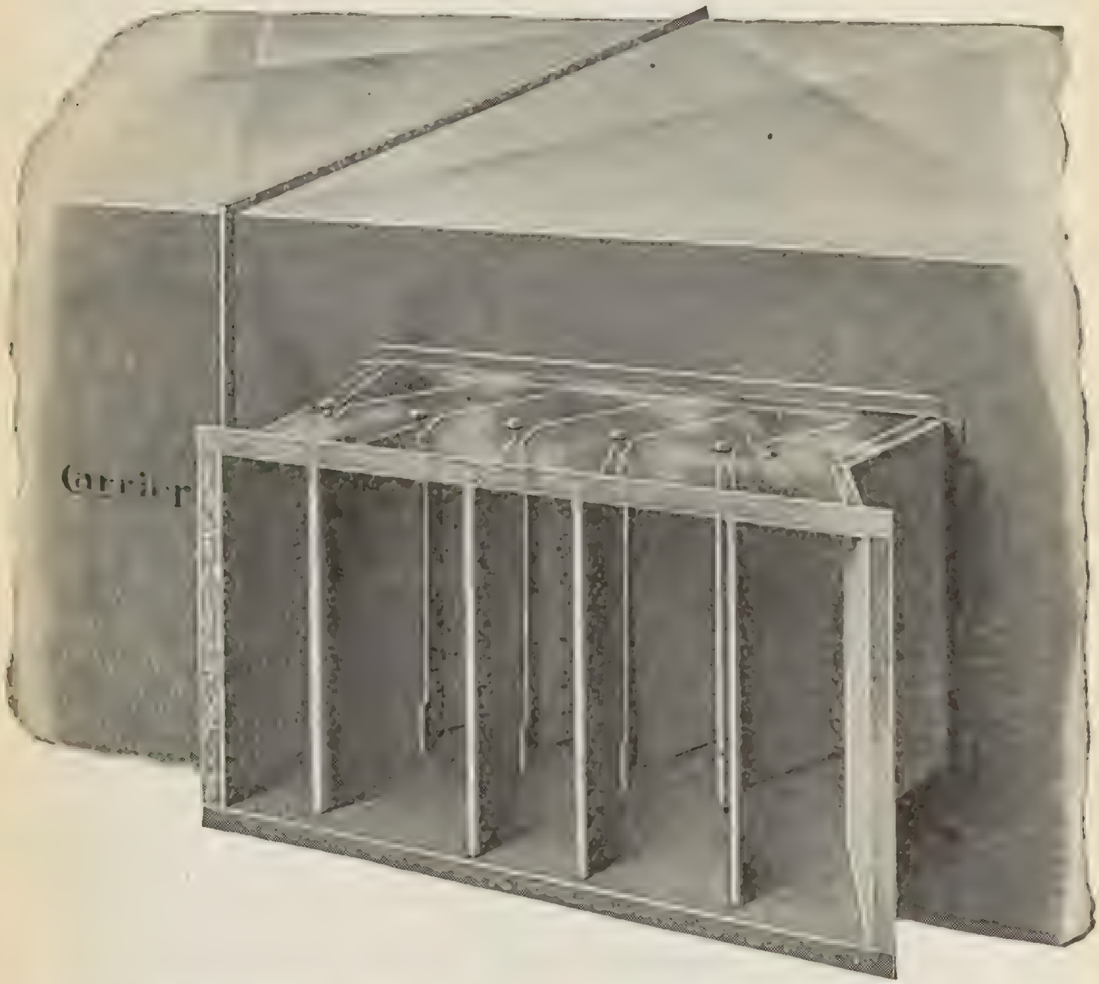


FIG. 8,722.—Carrier diffuser outlet (phantom view showing construction of the vanes).

Evaporative Cooling.—Since outdoor summer air is rarely fully saturated, there is usually a considerable difference between its dry bulb and its wet bulb temperature. This difference is called the wet bulb depression. Due to the higher dry bulb temperature of summer, the wet bulb depression is greatest during the summer season. As has been explained, the wet bulb temperature is that temperature to which air

would be cooled, by evaporation, if the air were brought into contact with water and allowed to absorb sufficient water vapor to become saturated.

Thus, if outdoor summer air be drawn through a humidifier, wherein it will be completely saturated, its dry bulb temperature will be reduced to its wet bulb temperature, and the air will leave the humidifier at the outdoor wet bulb temperature. This cooling is accomplished entirely by evaporation, and is due to the latent heat required to convert the liquid

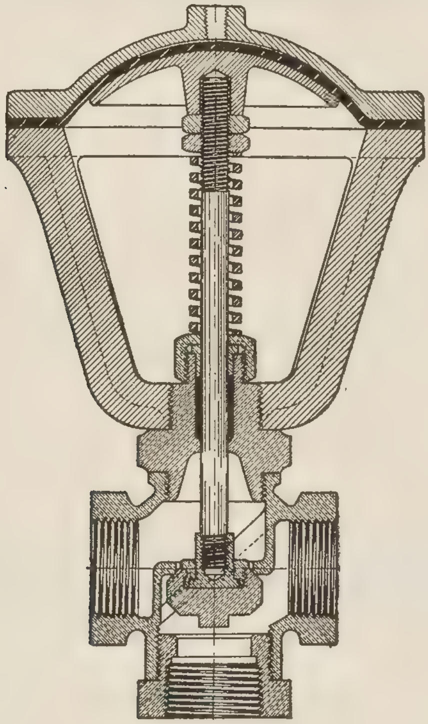


Fig. 8,723.—Carrier three-way diaphragm control valve used for dew point control in dehumidification.

water into water vapor, such conversion occurring the instant the air is brought into contact with the mist in the spray chamber of the humidifier, the heat being taken from the air.

The spray water in the humidifier is used over and over, only that quantity

being added which is actually absorbed by the air. Thus, without any additional operating expense, a humidifier will, in summer, perform the function of cooling the air through the wet bulb depression.

The wet bulb depression is often, in some localities as much as 25° or even 30°, and quite commonly from 10° to 15°, even in localities adjacent to great bodies of water, where the humidity is high and the wet bulb depression, therefore, correspondingly low. In the vicinity of New York, for instance, the maximum outdoor wet bulb temperature is about 78°.

On such a day the dry bulb temperature would probably be about 90°, the wet bulb depression being 90°-78°-120°. In Denver, where the maximum wet bulb is usually less than 78°, the coincident dry bulb is usually much higher than 90°, resulting in a greater wet bulb depression, which means that more cooling can be accomplished by evaporation.

CHAPTER 128

Domestic Water Supply

Water Sources.—For domestic use water is usually obtained from

1. Wells
2. Springs
3. City main

In some cases rain water is used by collecting the supply which falls on the roof.

There are numerous kinds of wells, as

1. Shallow
2. Deep
3. Artesian

The chief advantages of a well of large diameter are the storage that it affords and the possibilities of placing the pumps at a low level to obtain a short suction pipe.

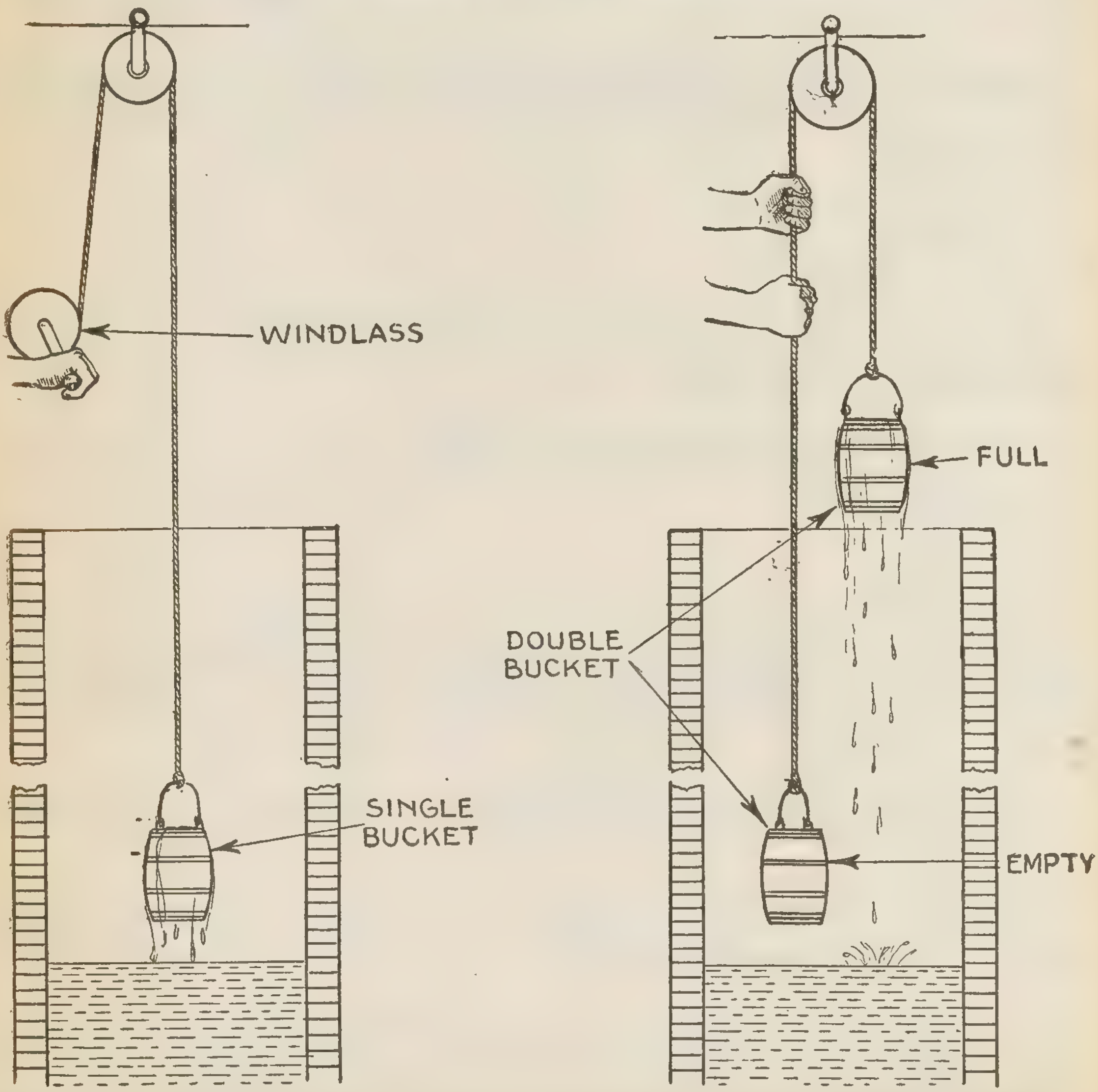
Large wells are useful especially in cases where the ground water flows through fine material with low velocity.

Dug wells avoid the clogging that occurs in driven wells located in iron bearing sands.

The ordinary driven well consists of a wrought iron or steel tube, 2 to 8 ins. diameter, with a strainer near the bottom. It is forced into the ground by a hammer or by the use of a falling weight or with the aid of a jet of water carried through a small pipe to loosen the material in advance of the point.

The strainers may be merely holes or slots in pieces of brass pipe, or larger holes in the pipe, covered with brass gauze. Porcelain strainers and tile wells also are used. The use of different metals in a strainer is objectionable, as it gives opportunity for galvanic action, causing corrosion and clogging.

The size of the openings must be adjusted to the texture of the soil. They must be small enough to prevent the entrance of any large quantity of sand but large enough to reduce the entrance velocity to a point where the friction will not be excessive; that is, less than about .2 ft. per second.



FIGS. 8.724 and 8,725.—Ordinary dug wells illustrating methods of raising water with: **1,** windlass and single bucket, and 2, by means of two buckets. Here the weight of the empty bucket descending reduces somewhat the exertion necessary to raise the full bucket.

Deep wells in soft material are bored. The loosened material is brought up by the use of a water jet or sand bucket; such wells are usually cased. Wells are bored in rock by the use of a cutting drill which is raised, revolved and let fall with a blow. Where strict artesian conditions prevail, a casing is put down to the impervious stratum.

Included in the class of driven wells are those known as artesian wells which penetrate through the earth to considerable depths.

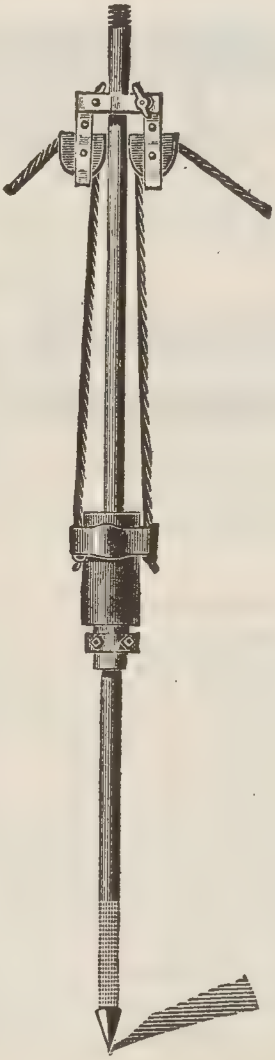


FIG. 8,726.—Driven well, showing pipes and perforated well point.

FIG. 8,727.—Method of driving pipe and perforated point with monkey.

Within reasonable distances ordinary driven wells are connected with the suction part of hand pumps. The process of driving these wells resembles pile driving, but with this distinction, that while piles receive the blows of the "monkey" on their heads, the tubes are not struck at all, the blow being communicated by the clamp, which receives the blow near the ground.

The tube well, as in ordinary use, is not intended for piercing rock or solid formations, but is quite capable of penetrating very hard and compact soils, and can be also successfully driven through chalk, breaking through the flints which may obstruct its passage downward.

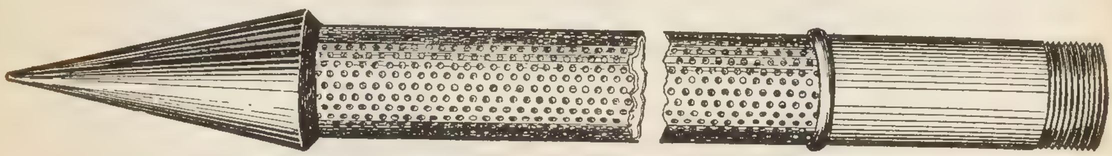


FIG. 8,728.—View of driven well point showing conical end and perforations through which water enters the pipe.

FIG. 8,729.—Sucker rod coupling used to connect ends of wooden sucker rods for *deep* well pumps. Each half of coupling is secured to the end of wooden rods by three bolts. The ends of the couplings are joined by male and female threads in the usual way. Either bolts or rivets may be used to attach the rods to the couplings.

When solid masses of rock or stone are reached, special means of drilling have to be provided for it. When coming upon rock or stone, the best plan is to pull up the tube and try in another spot. This applies also when deep beds of clay are driven into; for, by going a little distance off, and testing again, in many cases water will be found.

The operation is as follows: The first or pioneer tube, shown in fig. 8,726 is furnished with a steel point of bulbous form, and perforated with holes varying from one-eighth to an inch, extending from 15 in. to 3 ft. from the point, fig. 8,728. The enlargement of the point serves to clear a passage for the couplings by which the tubes are screwed together. On this tube the clamp fig. 8,727 is held about 3 ft. from the point by two bolts; the clamp is of wrought iron with steel bushing screwed internally so as to form teeth to grip the tube.

Next, the cast iron driving weight or monkey is slipped on to the tube above the clamp. The monkey is operated with ropes.

The method of securing water by rainfall on roofs is sometimes resorted to in rural districts as shown in fig. 8,730. It consists in leading the water from the roof to a tank in attic or cistern through suitable piping.

A valve is provided as shown so that the water may be directed either into the tank or into a leader. When the tank is full, the valve is turned so that the excess water will be carried off through the leader.

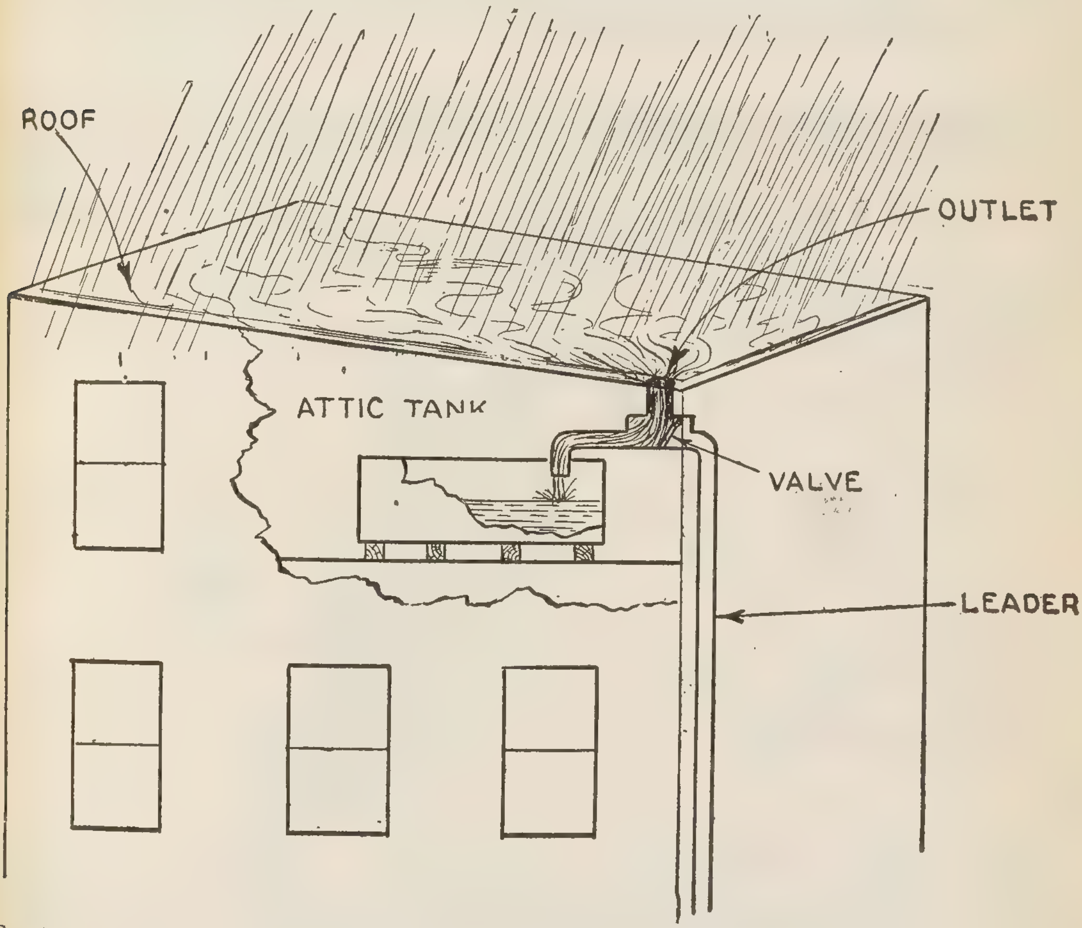


FIG. 8,730.—Rainfall system of water supply showing attic tank receiving its supply of water from roof, a valve being interposed as shown so that when the tank is full, excess water may be carried off through a leader.

This is an objectionable system, because the supply is uncertain and also, due to the considerable amount of dirt and other foreign matter which comes in with the water, the pipes frequently become clogged.

Evidently the most satisfactory source of water supply is

from the city main, when this is available. The only objections in some cases is: 1, the cost for the water; and 2, pressure too high to be safely carried through an old installation of lead piping. In the latter case, the pressure may be reduced either by the use of a reducing valve or where there is an attic tank, continuing the use of the tank by discharging the supply into the tank, maintaining a constant level in the tank by means of a float valve.

Domestic Supply Systems.—There are numerous methods of water supply for residences, due to the varied conditions met with. These domestic systems may be classed according to the method employed in raising the water, as by:

1. Hand pumps
2. Wind mill
3. Power pump

   a. Steam
   b. Gas engine
   c. Electric
   d. Hot air engine

   } drive

4. Hydraulic ram
5. Water wheel
6. Compressed air
7. Air lift

Hand Pumps.—The theory of all kinds of pumps has been given at considerable length in Guide No. 1 (see pages 1200 to 1206), and accordingly it is not necessary to go into it again here.

There are two general classes of pumps:

1. Lift
2. Force

The lift pumps are single acting; that is, water is delivered every other stroke.

Force pumps may be either single or double acting; when double acting water is delivered every stroke.

Perhaps the simplest and most primitive pump supply system employs the familiar box form of lift pump. Although these pumps are manufactured and largely used by farmers they can be made by anyone of ordinary mechanical ability, a hand made box pump being shown in figs. 8,731 and 8,732.

Fig. 8,733 shows the ordinary application of a box lift pump and as

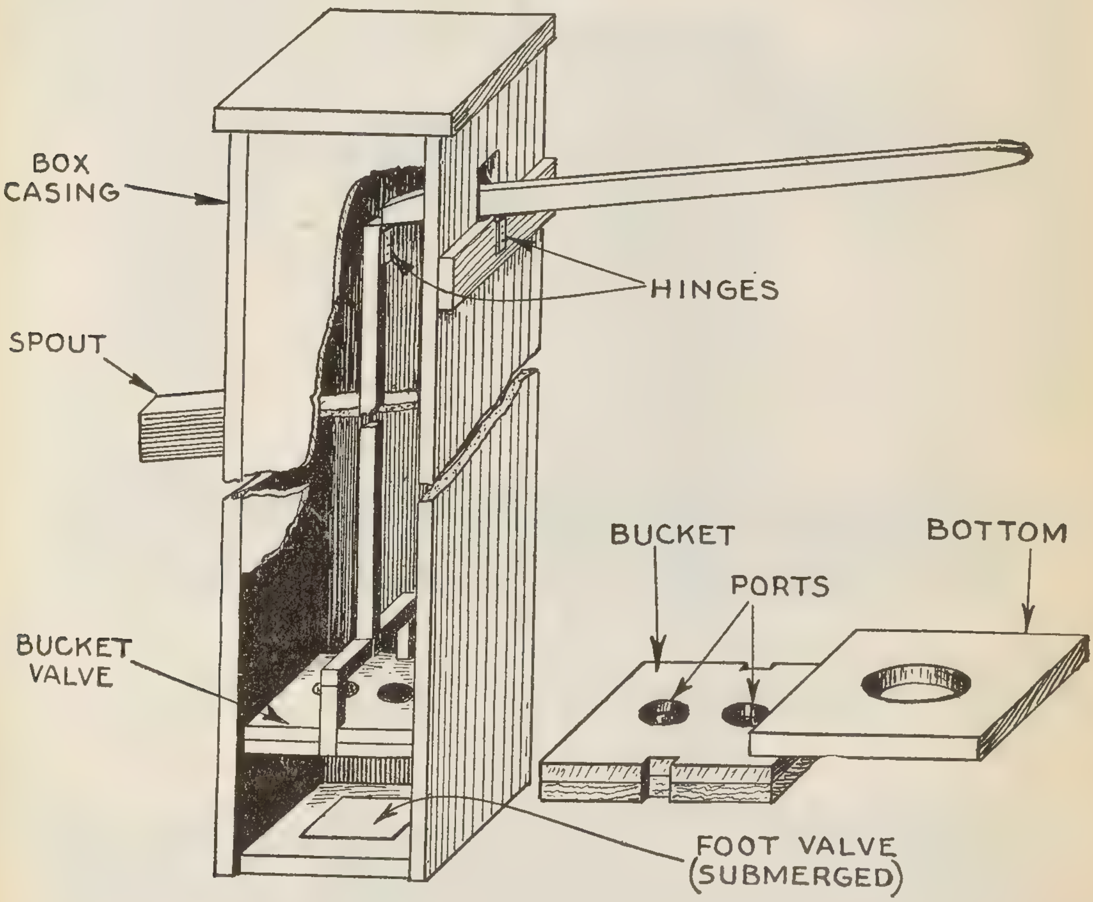


FIG. 8,731 and 8,732.—Home-made box lift pump, consisting of rectangular box fitted with a foot valve and having a bucket operated by a long wooden rod connected with a handle as shown. The handle is attached to the bucket rod by an ordinary hinge, another hinge being used for fulcrum. The valves may be made of leather and the bucket should be a nice fit with the box casing. To obtain this the edges of the bucket may be covered with leather.

seen, since the valves are below the level of the water in the well, the pump is always primed.

The barrel of a modern pump is a tube of metal having a water tight piston which moves freely up and down at the pleasure of the operator. This piston in its simplest form is made of cast iron in two parts.

The upper part consists of an arched part having a hole in its center

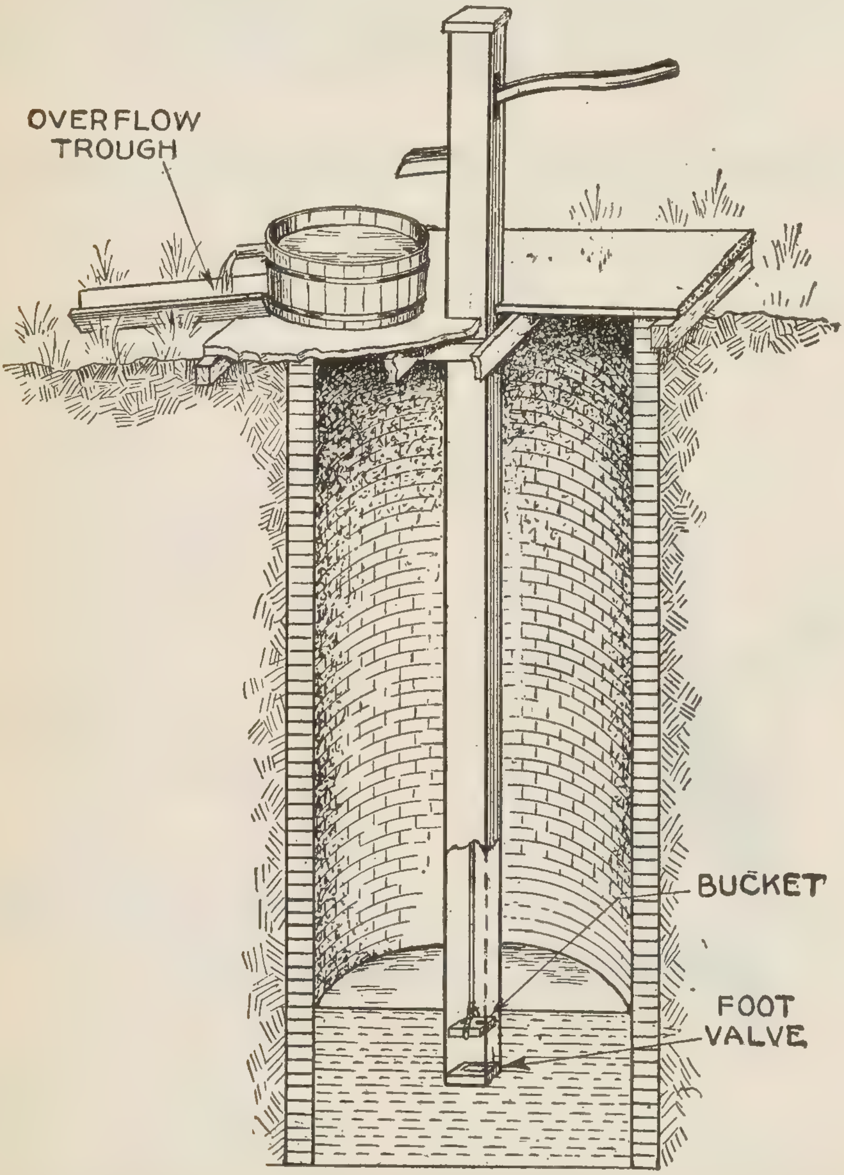
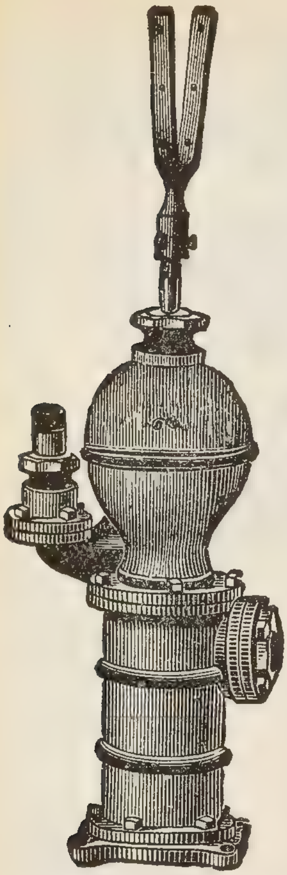


FIG. 8,733.—Installation of box pump over well. Below spout is usually placed half of a barrel provided with overflow outlet and trough to protect well from water draining back.



to receive a bolt which passes through it and a jaw on the lower end of the pitman or connecting rod.

The upper end of this pitman is attached to the pump handle by means of a bolt. The inside of the upper part of the plunger is threaded to receive the lower part with a cup leather packing and contains a valve of metal having a conical seat.

Between the upper and lower parts of the plunger a cup leather is introduced before these parts are screwed together. This cup leather, while it allows the plunger to move freely, also makes a water-tight joint.

The lower valve consists of a piece of cast iron flat on the bottom and circular in shape about three-eighths inch thick with a curved toe at one side. This iron disc is secured to the flat leather valve by a screw that passes through the valve and is threaded in the disc. The object of this

FIG. 8,734.—Columbiana syphon force pump with submerged cylinder. This working head is built for heavy service. It is intended for installations where it can be placed within 25 ft. of the water, the cylinder bing submerged. It is always primed. Proper protection against frost must be afforded.

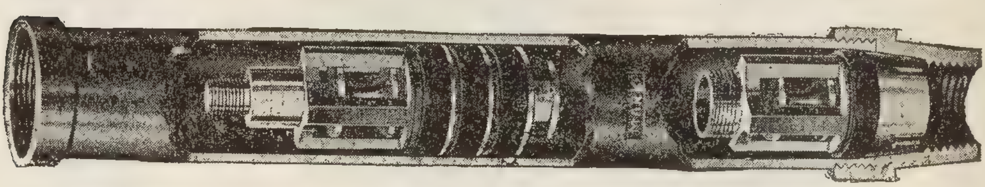


FIG. 8,735.—Columbiana deep well brass lined cylinder. ***In construction,*** the check valve is seated on a shoulder in a special coupling at the lower end of the cylinder. The plunger and lower valve can be inserted or removed through the connecting pipe, which is larger in diameter than the bore of the cylinder.

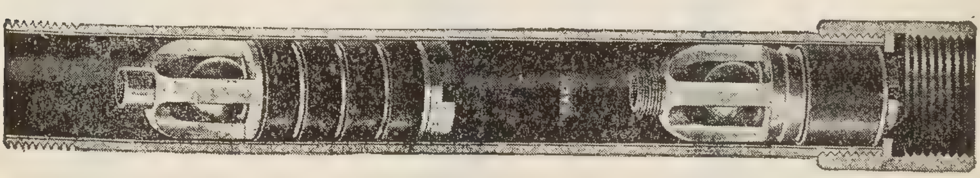


FIG. 8,736.—Columbiana all brass deep well cylinder with spool or ball valves. This cylinder may be placed in open wells and in drilled wells where the pipe, or casing, is large enough to take the cylinder attachments.

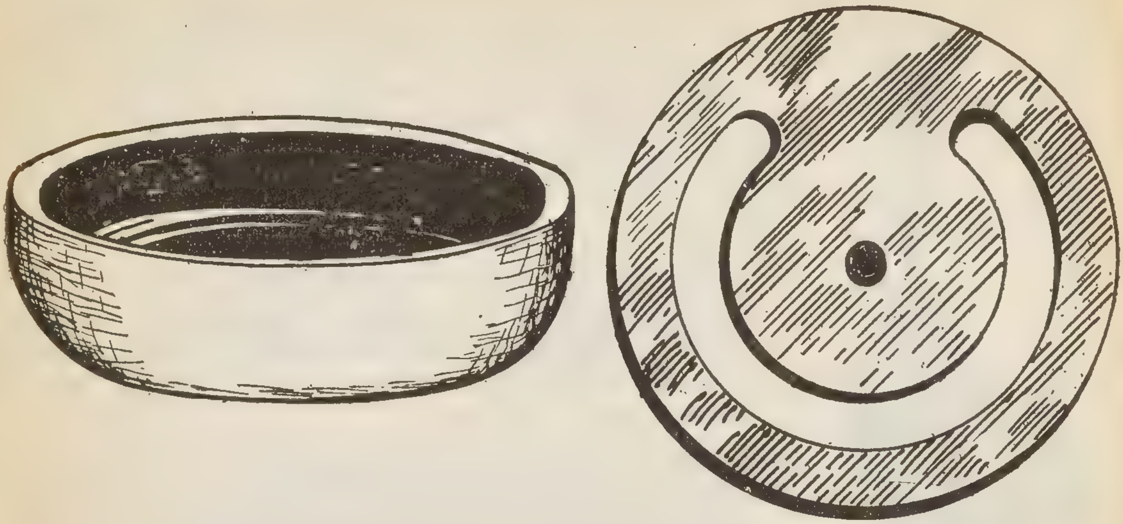
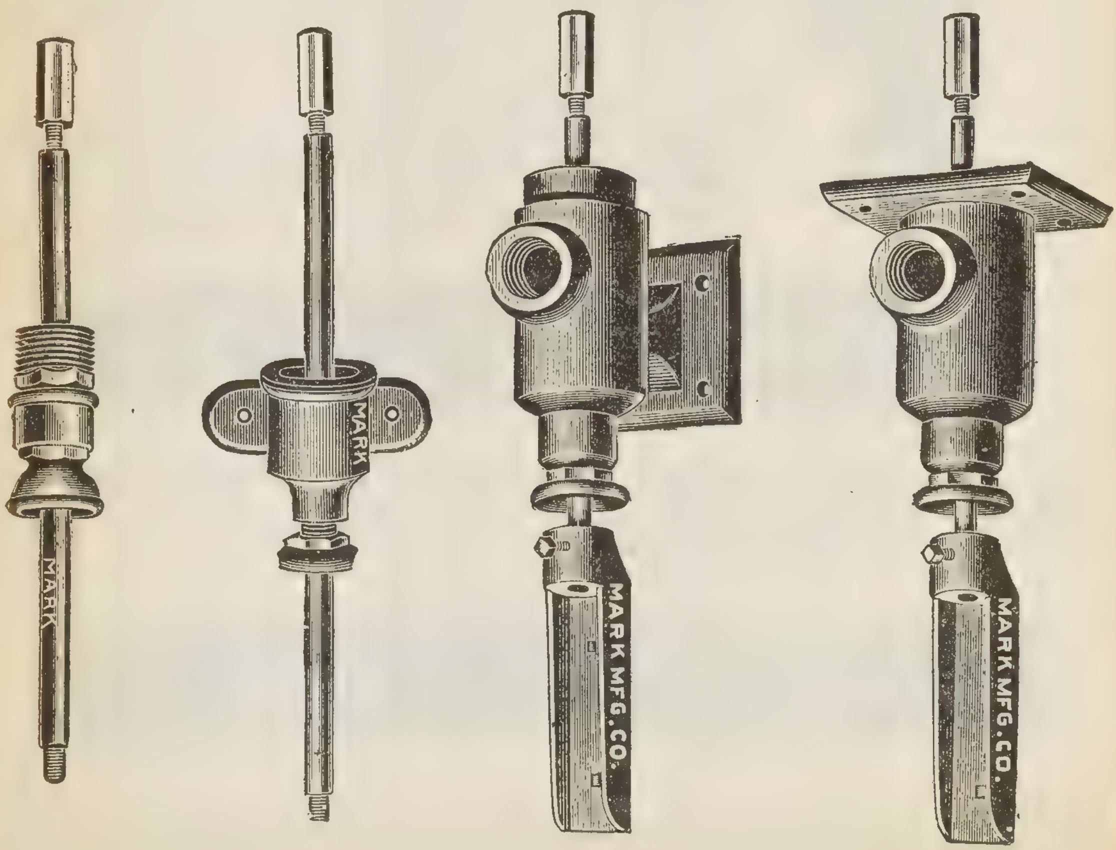


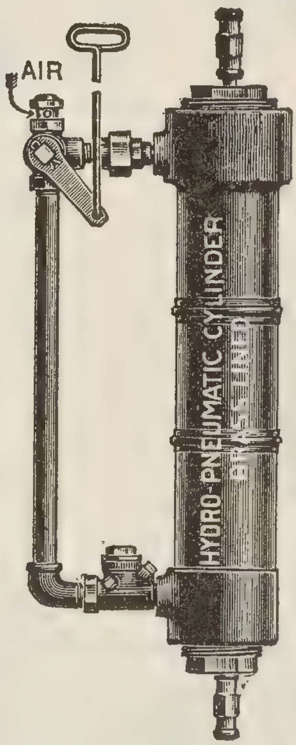
FIG. 8,737 and 8,738.—Pump leathers. Fig. 8,737, cup leather; fig. 8,738, lower valve leather.



FIGS. 8,739 to 8,742.—Butler wind mill stuffing box heads.

toe upon the disc is to open the lower valve by means of raising the pump handle as far as it will go which lowers the plunger upon the toe and tips the lower valve upon its seat. This same operation also lifts the valve in the plunger off its seat, so that all the water in the barrel drains back into the well so the pump is kept from freezing up in winter.

The leather which forms the lower valve is held in place by clamping the pump barrel upon it, so that it is heid between the barrel and the base plate.



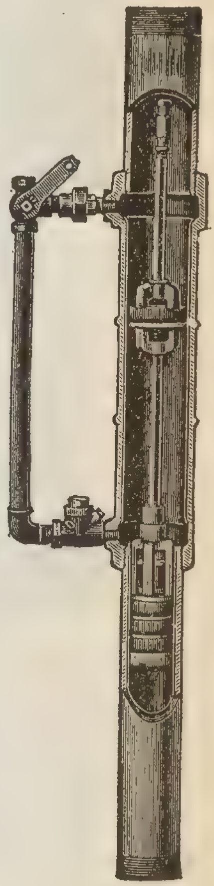
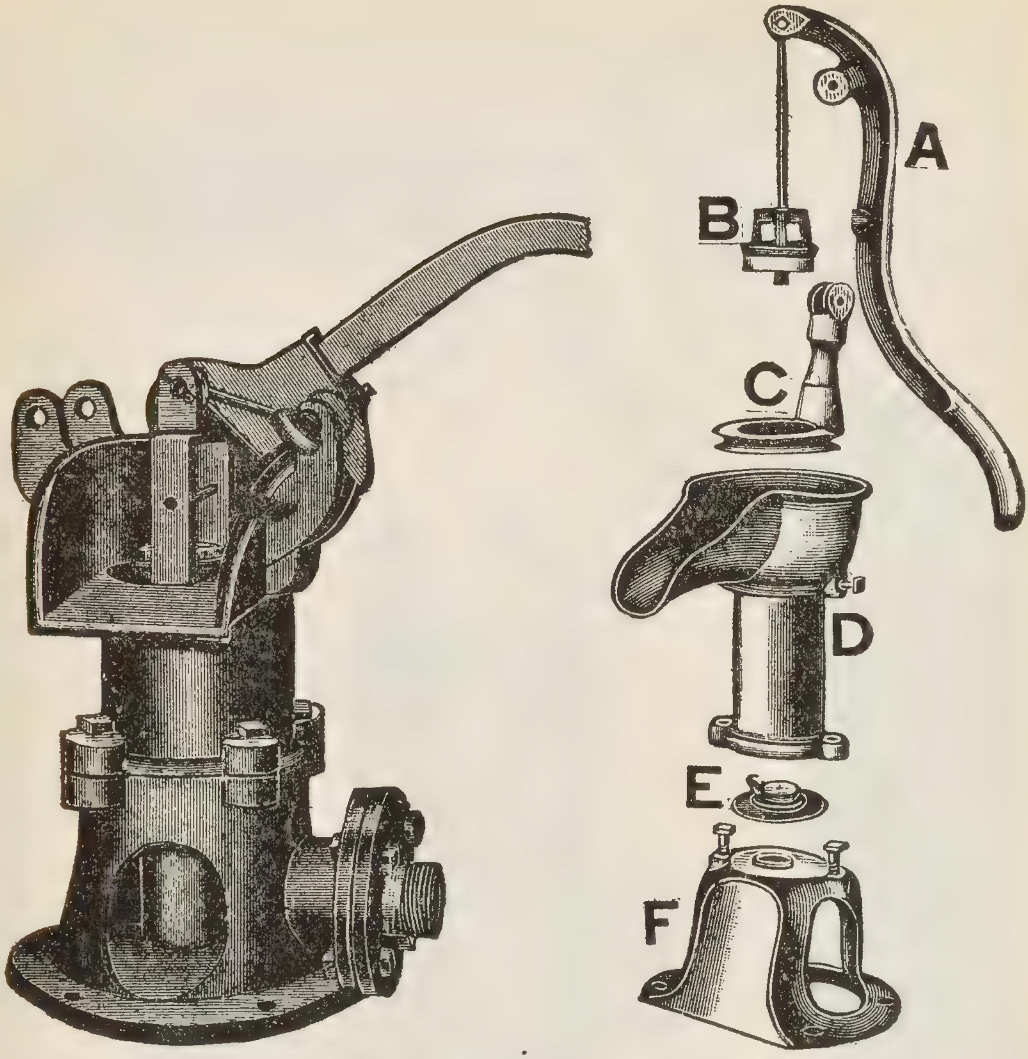


FIG. 8,743.—Butler iron pump cylinder showing bucket, bucket valve and foot valve.

FIG. 8,744.—Butler hydro-pneumatic cylinder for open wells. This cylinder can be used in connection with any underground force. It is located immediately below the pump proper.

FIG. 8,745.—Butler hydro-pneumatic cylinder as used on tubular well where pistons can be withdrawn.



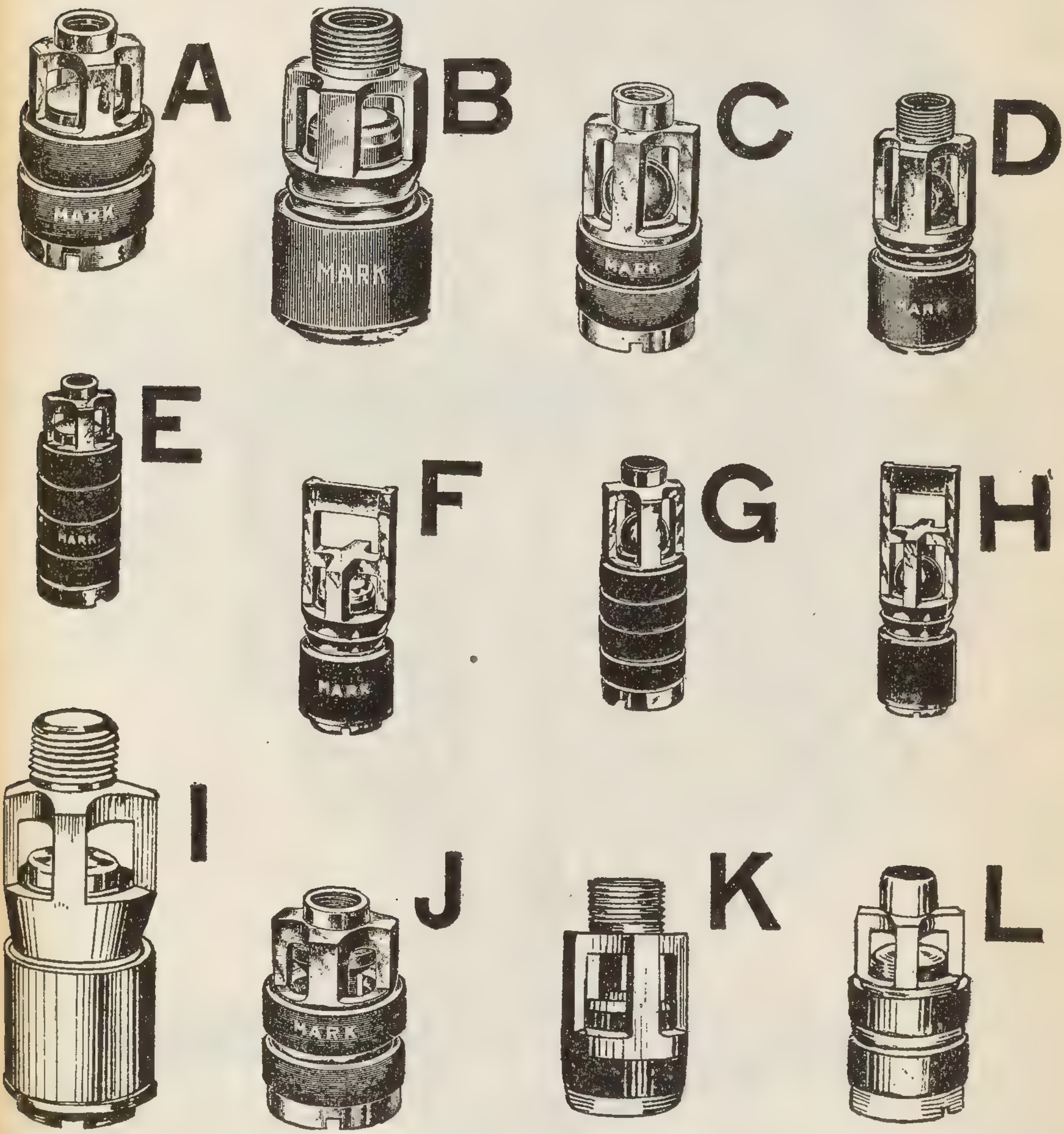
FIGS. 8,746 to 8,751.—Ordinary cast iron lift or "spout" pump. ***The parts are*** A, lever or handle; B, bucket, which contains the discharge or bucket valve and is made tight by a cup leather packing; C, fulcrum for lever; D, barrel or cylinder; E, base. The leather which forms the valve E, also makes the joint between the cylinder and the base.

NOTE.—When a pump fails to start after standing for some time it should be primed by filling the barrel with water and starting the pump slowly. If after priming, it fail to raise water, the suction pipe should be examined and also the plungers and the valves. If the plunger packing has become dry and hard merely filling the water end with water will not at once remedy the trouble because the packing must be thoroughly soaked before it will work properly.

NOTE.—Packing should fit the grooves in solid pistons moderately tight, so that the packing can be pushed into the grooves with the fingers. The depth of the packing should be such that the piston will fit the bore of the water cylinder snugly when first put in. If packing of the proper depth cannot be obtained, it is better to have the grooves turned to receive standard sizes of packing and not require special sizes. Cutting hydraulic packing is a tedious job, consuming a great deal of unnecessary time.

Figs. 8,746 to 8,751 show the construction of an ordinary lift or "spout" pump.

Wind Mills.—As a source of energy wind power is of



Figs. 8,752 to 8,763.—Various tubular well bucket pistons or so called valves. These pistons are not plungers as persistently and erroneously called by some. **A,** Mark piston; **B,** Mark check; **C,** ball piston; **D,** ball check; **E,** four-leather piston; **F,** bail top check; **G,** four-leather ball piston; **H,** bail top ball check; **I,** marine perfection check valve; **J,** Morris perfection piston; **K,** Eureka check; **L,** Eureka piston.

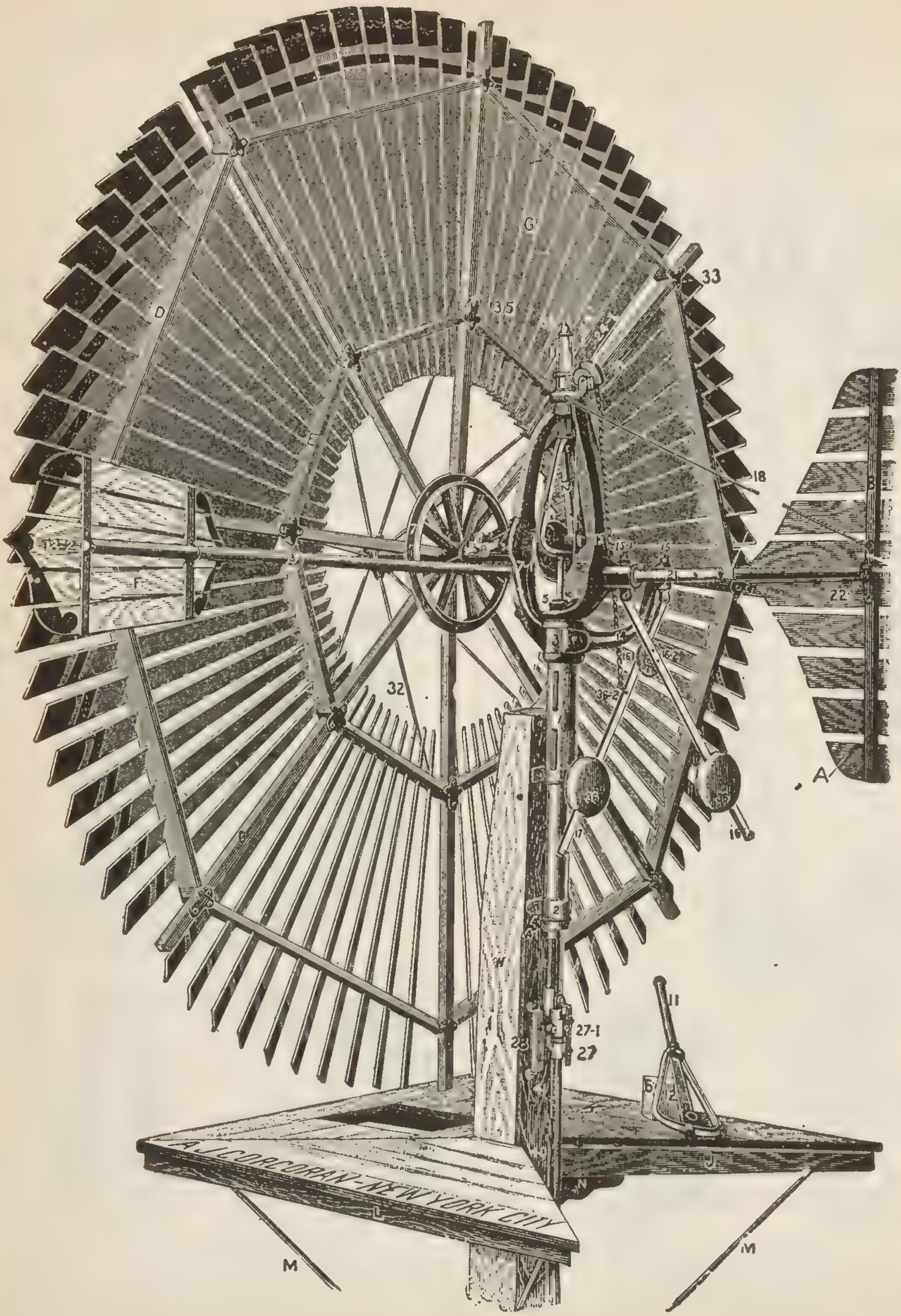


FIG. 8,764.—Corcoran direct stroke wind mill with wooden vanes. ***In construction,*** the mill is made mostly of steel, wrought and malleable iron, the whole central iron work being

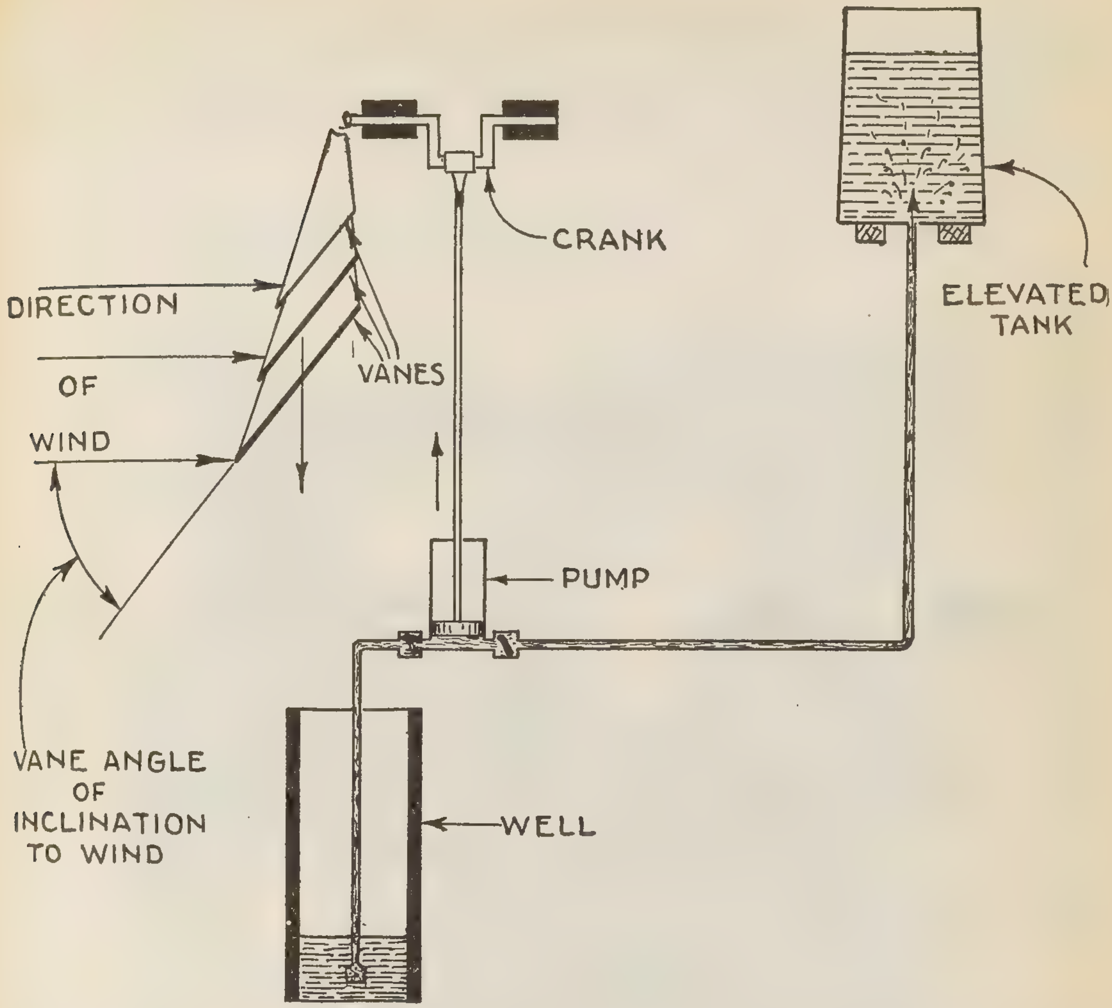


FIG. 8,765.—Essentials of wind mill operation showing vanes inclined to wind also crank and pump connections.

Fig. 8,764.—*Text Contined.*

concentrated in the main frame No. 3, which is a piece of wrought iron hydraulic tubing with the bearing frame which supports the wind wheel shaft cast upon it. No. 3 rests and turns on an anti-friction washer, and the hydraulic tube No. 3 passes down through guide No. 2 and is held firmly in place by collar No. 4, on the bottom of No. 3. The object of this tubing coming down the mast H as far as the point on the wind mill arm H, is to give the main frame of wind mill equal leverage with the strain brought upon the arms C, thereby preventing any rocking motion of the mill or mast in variable winds, or working of the crank on the various centers, all being supported in the same frame and effectually kept in line, and to entirely obviate the possibility of their being blown away. The pitman No. 10 and 11, work in bearings lined with the Babbitt metal, so that in case of wear from neglect of oiling, the part, instead of being thrown away, can be relined by any ordinary mechanic.

importance, especially for pumping water in suburban or rural districts which have no city water supply.

The operation of a wind mill is due to the pressure of the

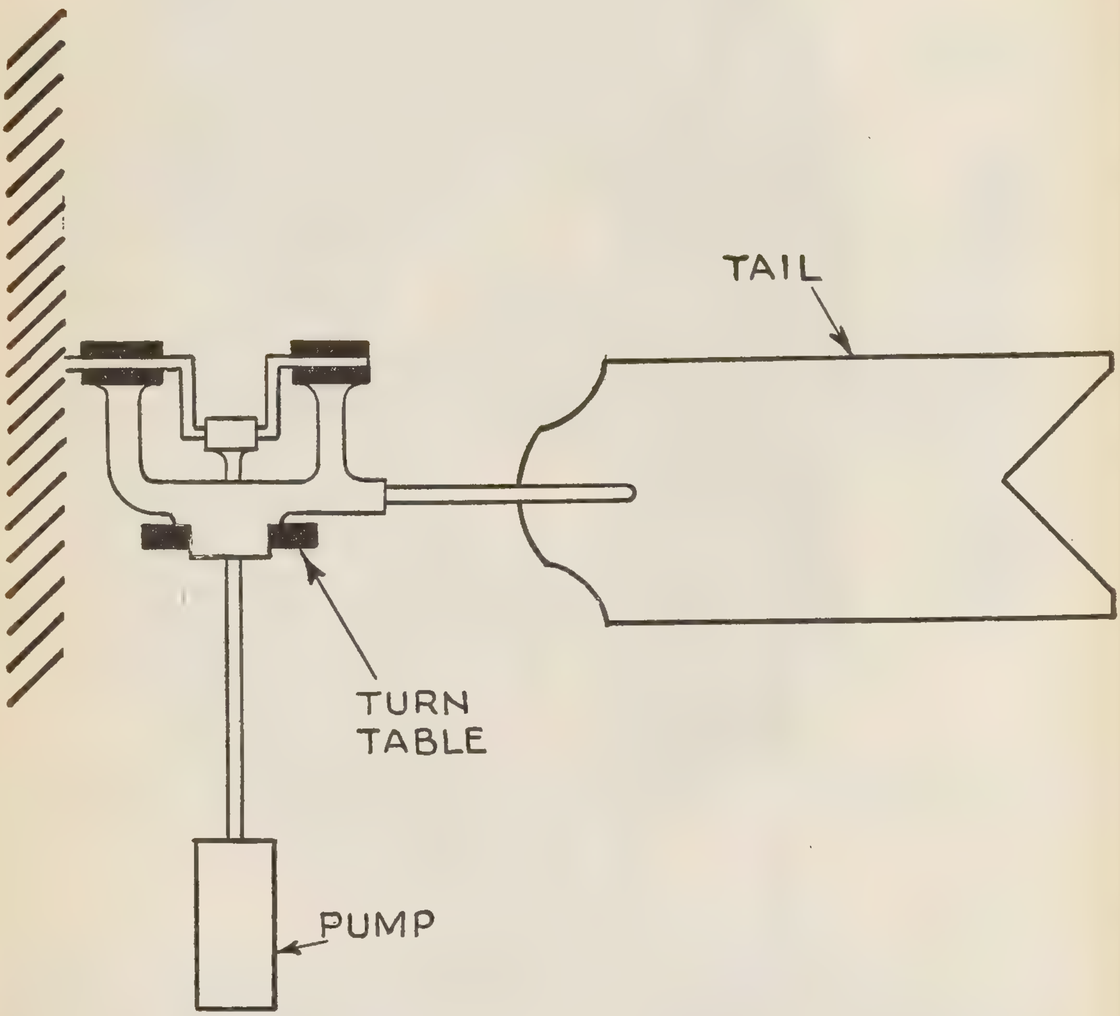


Fig. 8,766.—Elementary wind mill showing turntable and tail.

wind acting on numerous vanes inclined to the direction of the wind and rotating in a plane perpendicular to the direction of the wind as shown in fig. 8,776.

For maximum effect the plane of the wheel must be kept perpendicular to the direction of the wind. To accomplish this, the main casting on which the wheel is pivoted is arranged to turn in a stationary collar or turntable as shown in fig. 8,766. This turning is controlled by a tail attached to the main casting and upon which the wind acts.

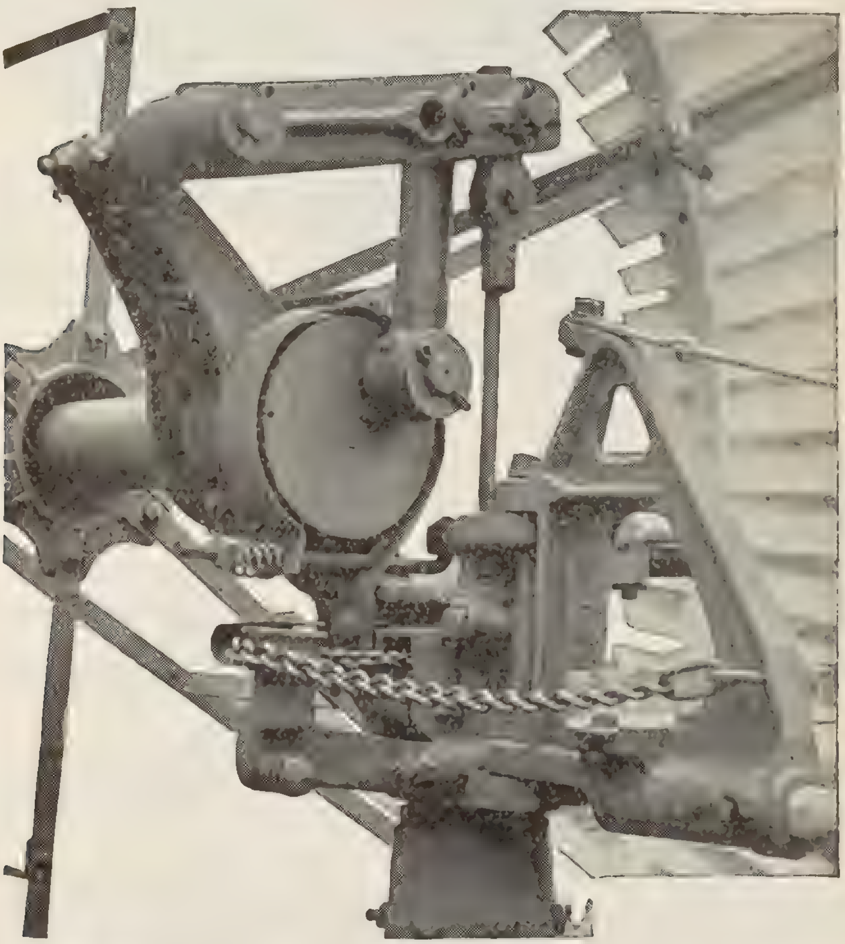


FIG. 8,767.—Challenge ***augmented stroke*** wind mill with wood or steel wheel, showing stroke increasing mechanism and band brake. Hard wood, self-oiling bearings, or Hyatt roller bearings are used as desired.

There are upon the market a multiplicity of types of wind mills and they may be classified:

1. With respect to the power transmission, as

a. Direct stroke
b. Augmented stroke
c. Geared

2. With respect to direction control, as

a. Tail or vane
b. Vaneless

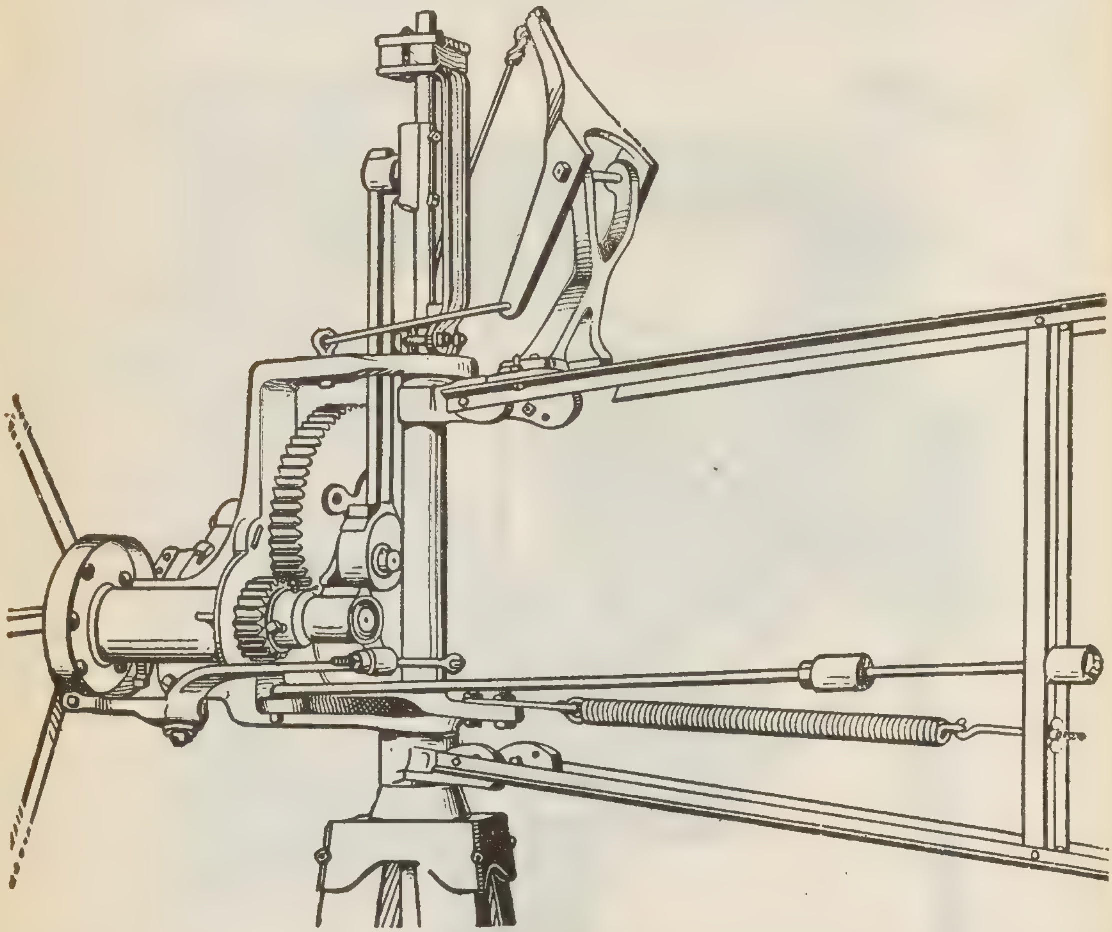


FIG. 8,768.—I X L single geared wind mill. The gear ratio is 3:1, but it may be reduced to 2½ or 2:1 without removing mill from tower as the main casting is made in two parts which are adjustable.

3. With respect to the material of construction, as

a. Wooden
b. Metal

Evidently some means must be provided for controlling the

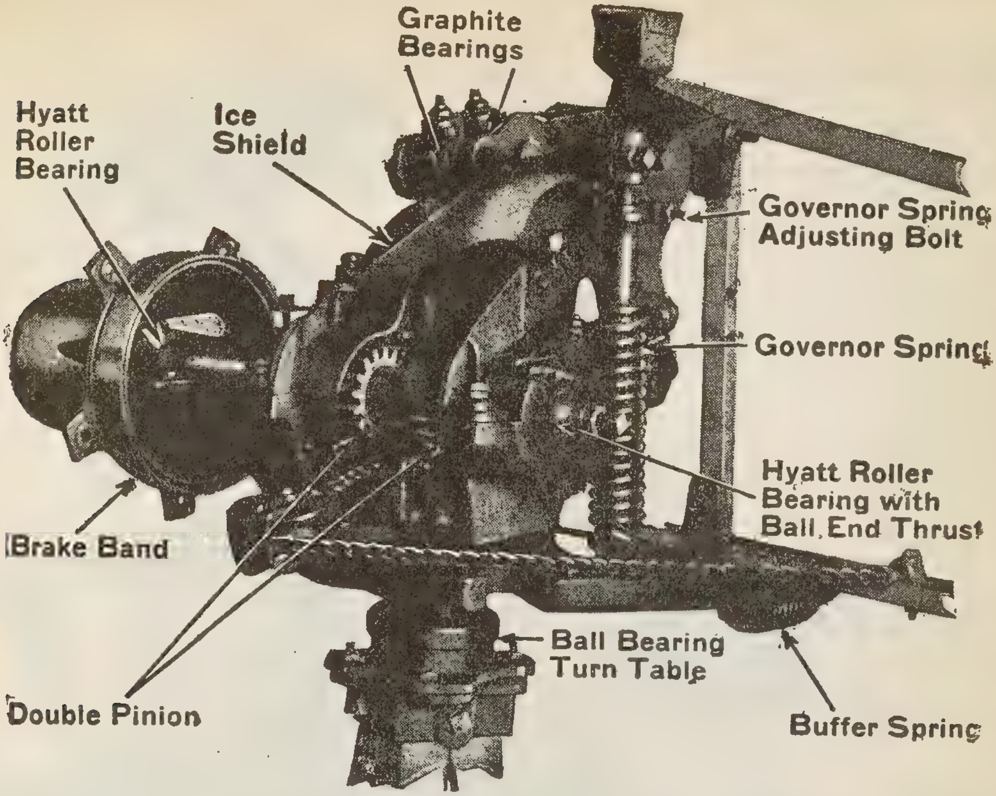


FIG. 8,769.—Samson double geared wind mill; assembled head complete.

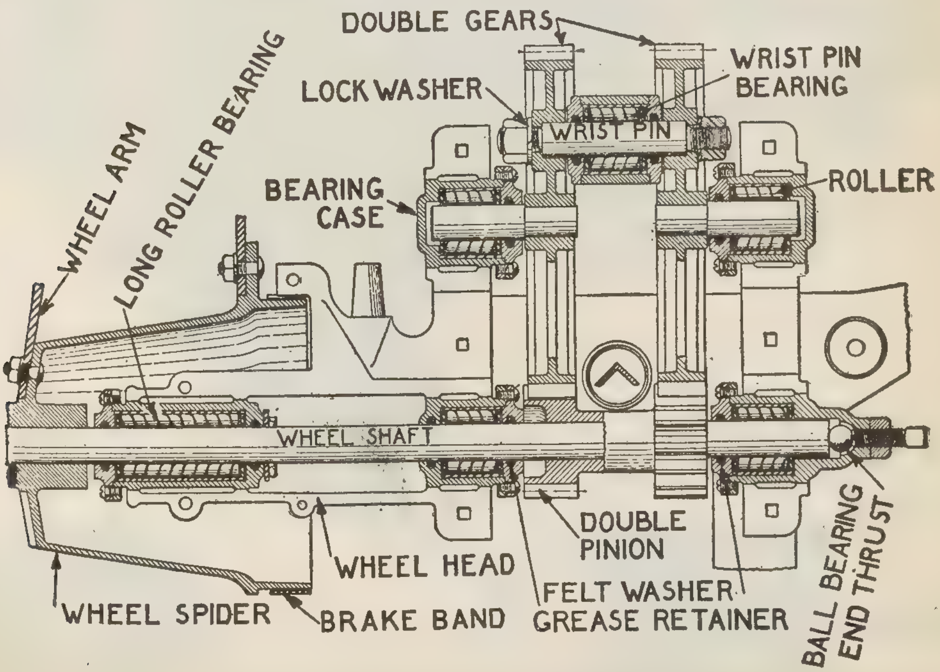
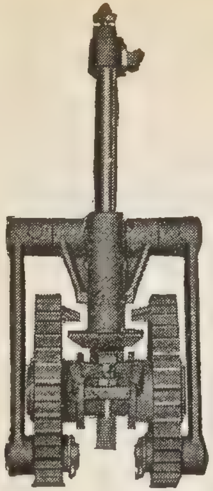
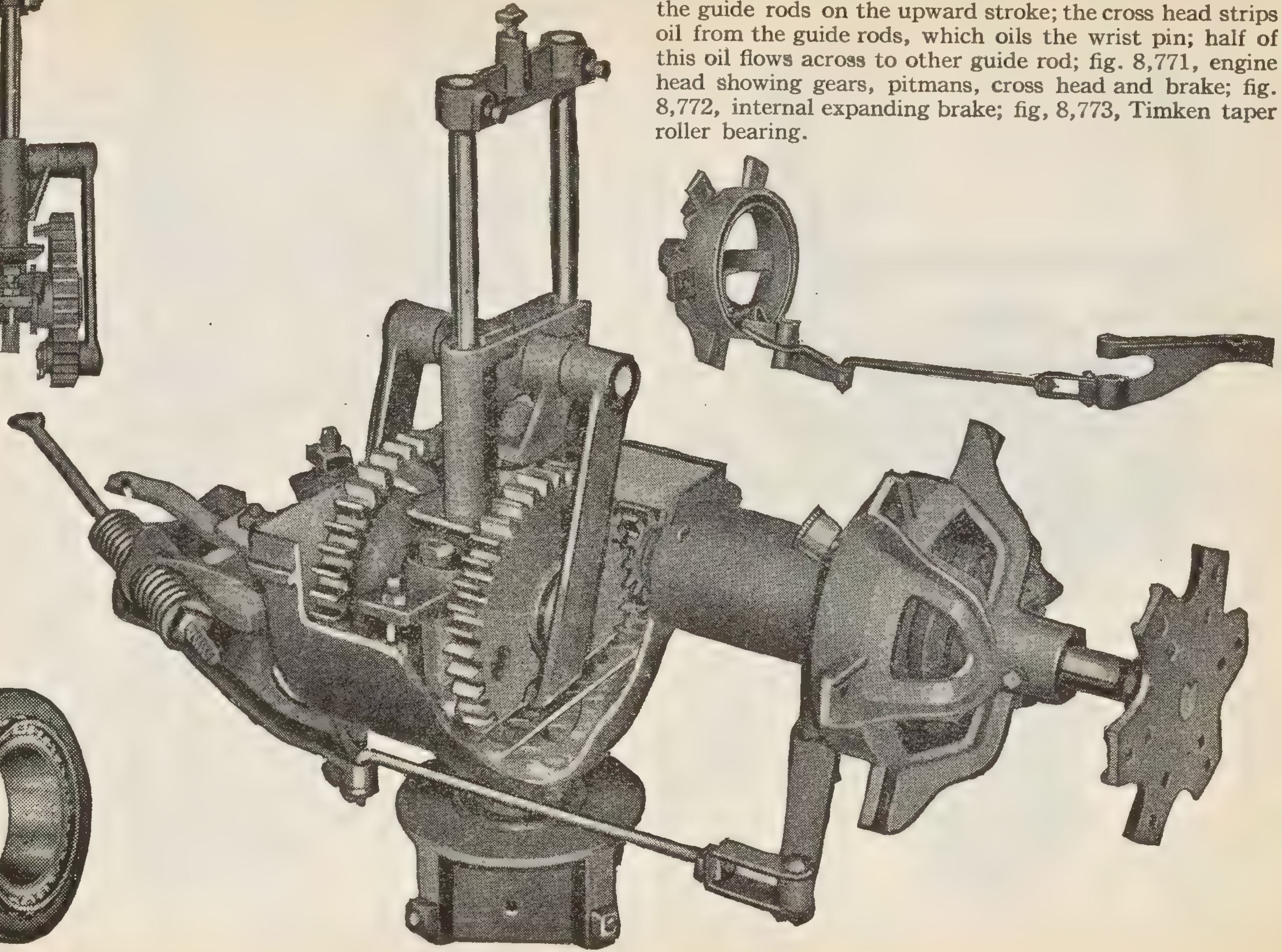
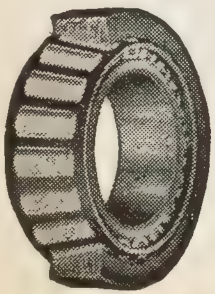


FIG. 8,770.—Sectional view of Samson double geared wind mill showing double gears and Hyatt roller bearings.

FIGS. 8,770 to 8,773.—Dempster improved double geared wind mill construction. Fig. 8,770, cross head. The oil from the long cogs drips into the pan on cross head; holes from this pan allow the oil to flow onto the guide rods on the upward stroke; the cross head strips oil from the guide rods, which oils the wrist pin; half of this oil flows across to other guide rod; fig. 8,771, engine head showing gears, pitmans, cross head and brake; fig. 8,772, internal expanding brake; fig, 8,773, Timken taper roller bearing.







speed of the mill, otherwise in case of very high wind, damage may result.

Numerous methods of speed control are employed as by use of

1. Weight governor
2. Inclined tail
3. Pivoted vanes

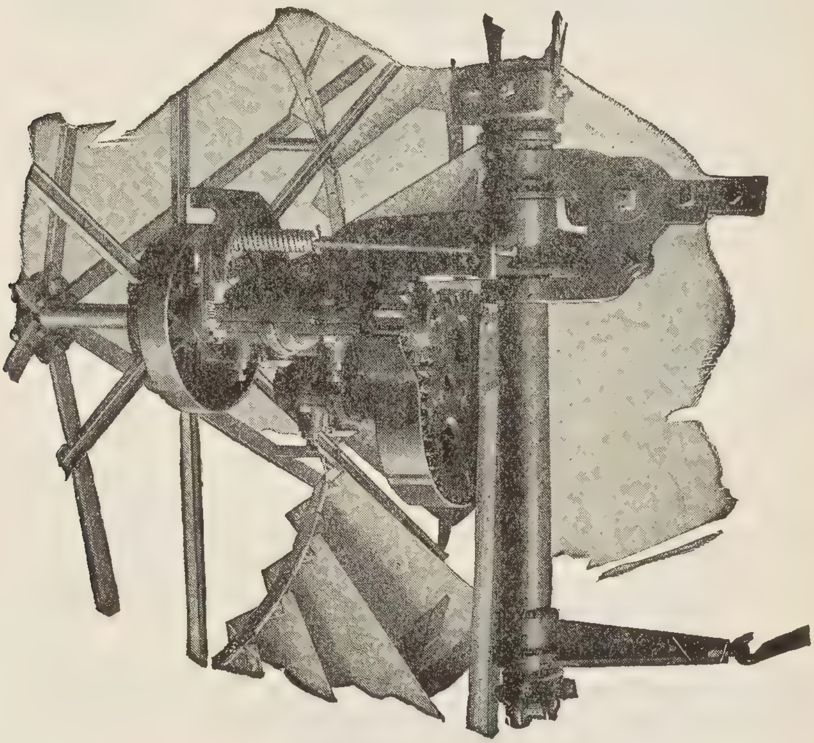


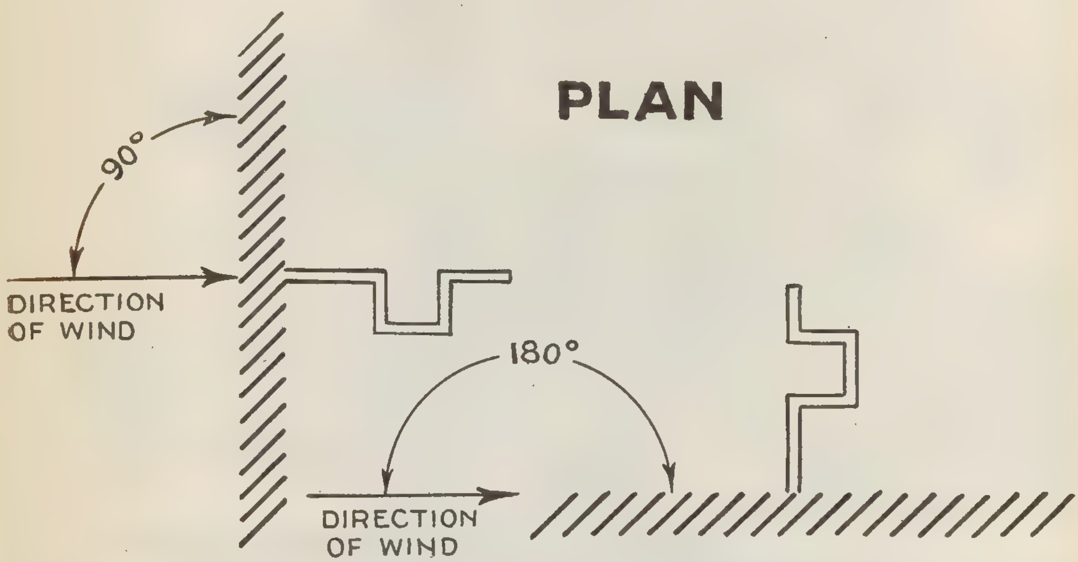
FIG. 8,775.—Appleton-Goodhue single geared wind mill.

In considering speed control it should be understood that the wind has the maximum turning effect on the wheel when it is perpendicular to the direction of the wind and has no effect when parallel, as shown in figs. 8,776 and 8,777.

The method of speed control by governor balls is shown in figs. 8,778 and 8,879, and by inclined tail in figs. 8,780 and 8,781.

These two methods are applied to wheels having vanes rigidly attached to the wheel spokes.

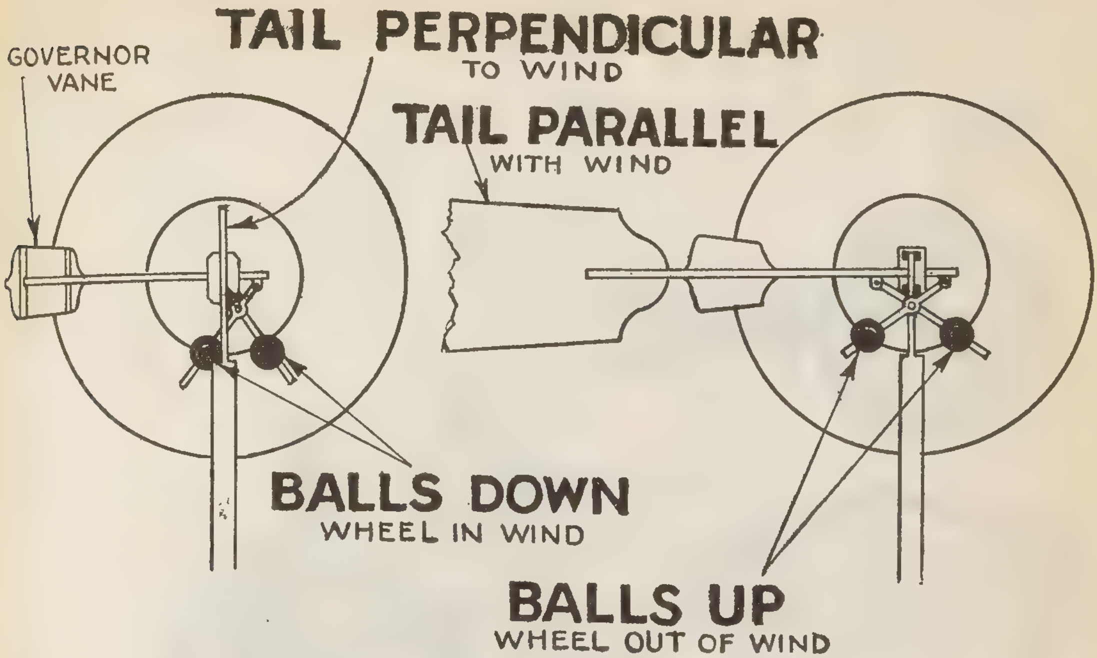
The so called "vaneless" (meaning tailless) wind mills have pivoted vanes which turn out of the wind by centrifugal force instead of gravity, the controlling force of the other two types. A suitable mechanism is employed to hold the vanes out of the wind against the tension of the springs, when it is desired to shut off the mill.



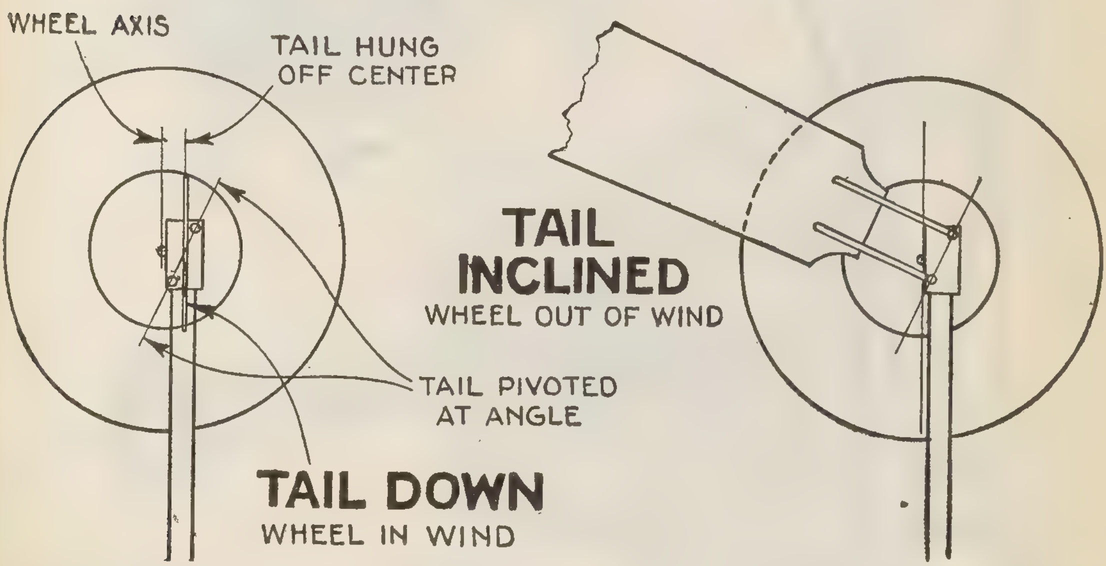
FIGS. 8,776 and 8,777.—Effect of inclination of wheel to direction of the wind. Fig. 8,776, wheel perpendicular to direction of the wind, effect maximum; fig. 8,777, wheel parallel to direction of the wind, effect minimum (zero).

Properties of the wind.—*The velocity of the wind determines its pressure,* and the pressure of the wind against the sails of the wind mill determines the power developed by the mill. A mill of small diameter acted upon by a high pressure develops as much power as a large mill working under a lower pressure.

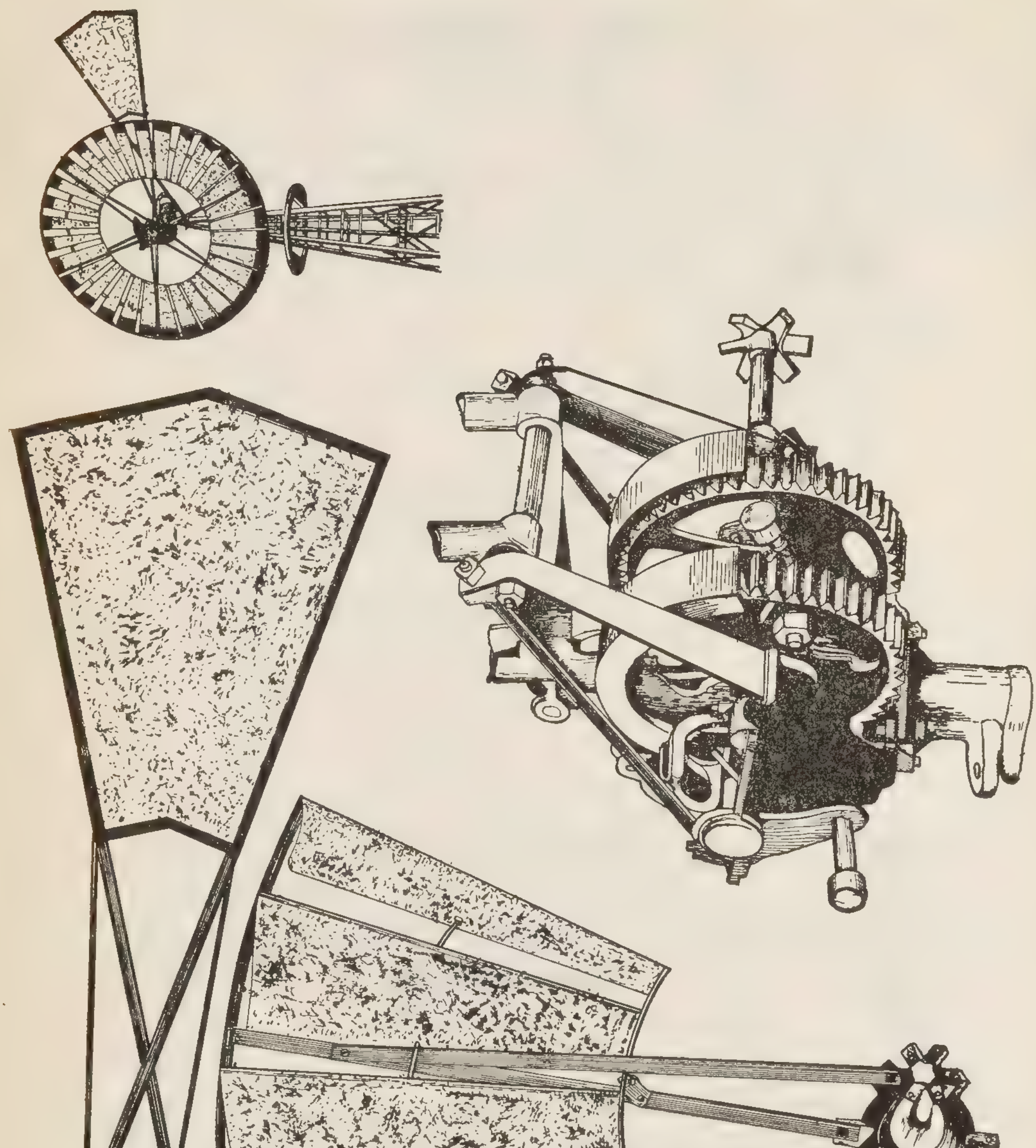
The mean average velocity of the wind for the entire United States is very nearly eight miles per hour. However, for large areas such as the great



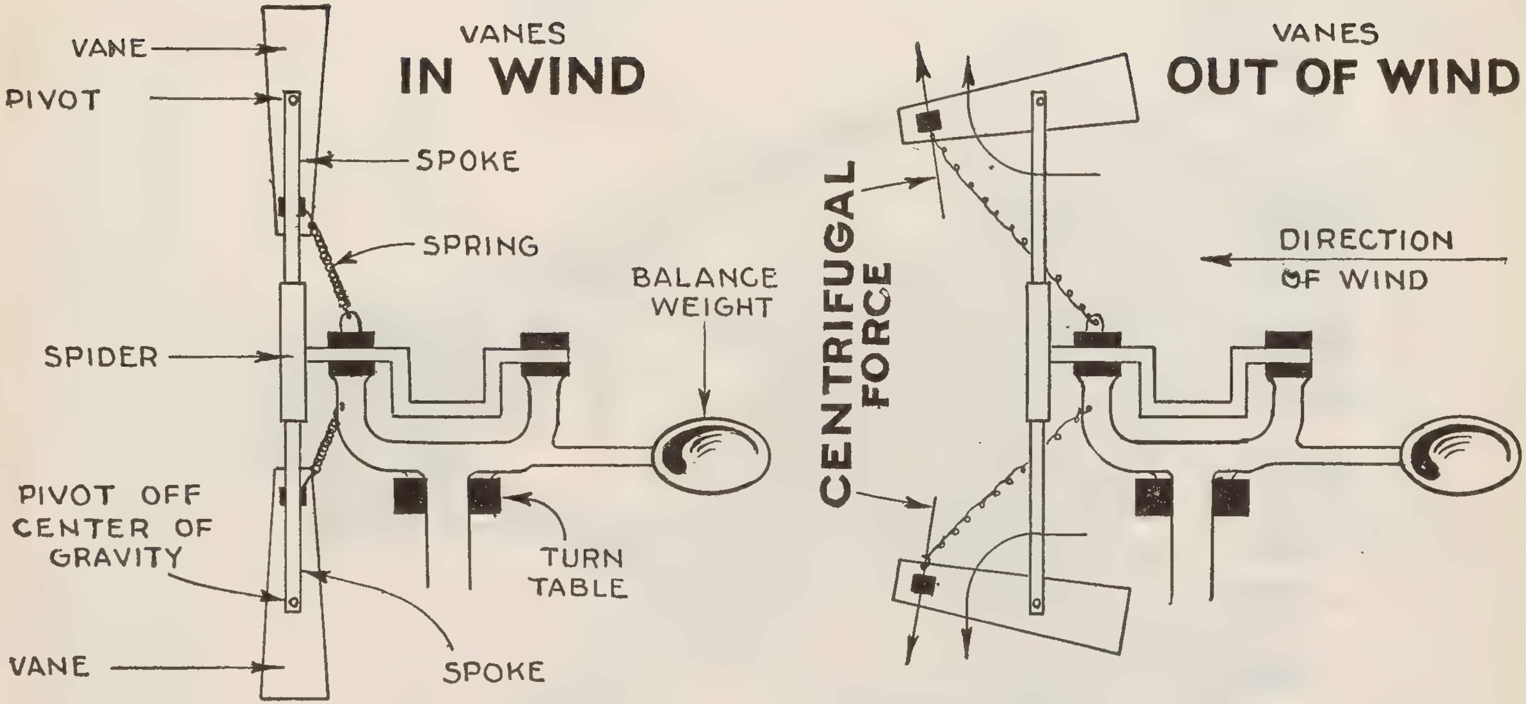
FIGS. 8,778 and 8,779.—Speed control by ball governor. Fig. 8,778, wheel in wind; fig. ,8779 wheel out of wind.



FIGS. 8,780 and 8,781.—Speed control by inclined tail, wheel pivoted off center. Fig. 8,780 wheel in wind; fig. 8,781, wheel out of wind. ***In operation,*** the wheel being pivoted off center with respect to the turntable, tends to cause it to turn out of the wind, and in so doing the tail is lifted into an inclined position, on account of being pivoted at an angle with the vertical. Gravity acts to bring the wheel back into the wind.



FIGS. 8,782 to 8,785.—Perkins *inclined tail* wind mill construction. Fig. 8,782, inclined tail showing pivots; fig. 8,783, wheel section showing three point support; fig. 8,784, wheel out of wind showing tail in inclined position; fig. 8,785, engine head.



Figs. 8,786 and 8,787.—Speed control by pivoted vanes as employed on the so called vaneless (tailless) mills. The vane sections are hinged off their center of gravity. As the speed of the wheel increases, the weight of the sections turns them out of the wind. Fig. 8,876, shows the vanes *in wind* and fig. 8,787, *out of wind*.

plains east of the Rocky Mountains, the mean average is about eleven miles per hour, and yet in certain small areas situated in the mountainous districts the mean average velocity is as low as five miles per hour. Therefore, in selecting and loading a mill, reference should be had to the wind velocity prevailing in that particular locality. In general, wind mills

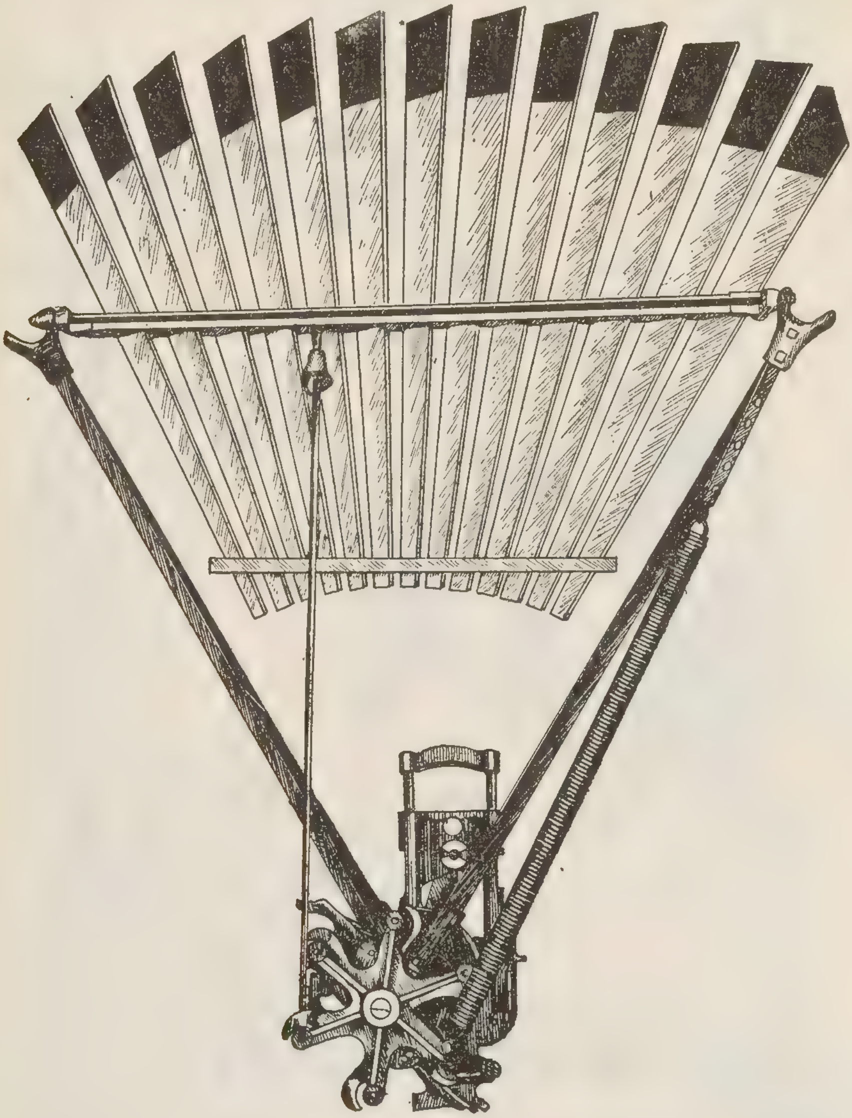


FIG. 87,88.—Dempster vaneless wind mill wheel section with section *in wind* showing arms with governing spring and shipper rod in position. The six pointed spider rotates on the shaft in governing the mill.

loaded to operate in ten-mile winds can be depended upon to furnish a sufficient supply of water.

If the wind were to blow continuously a very small windmill would

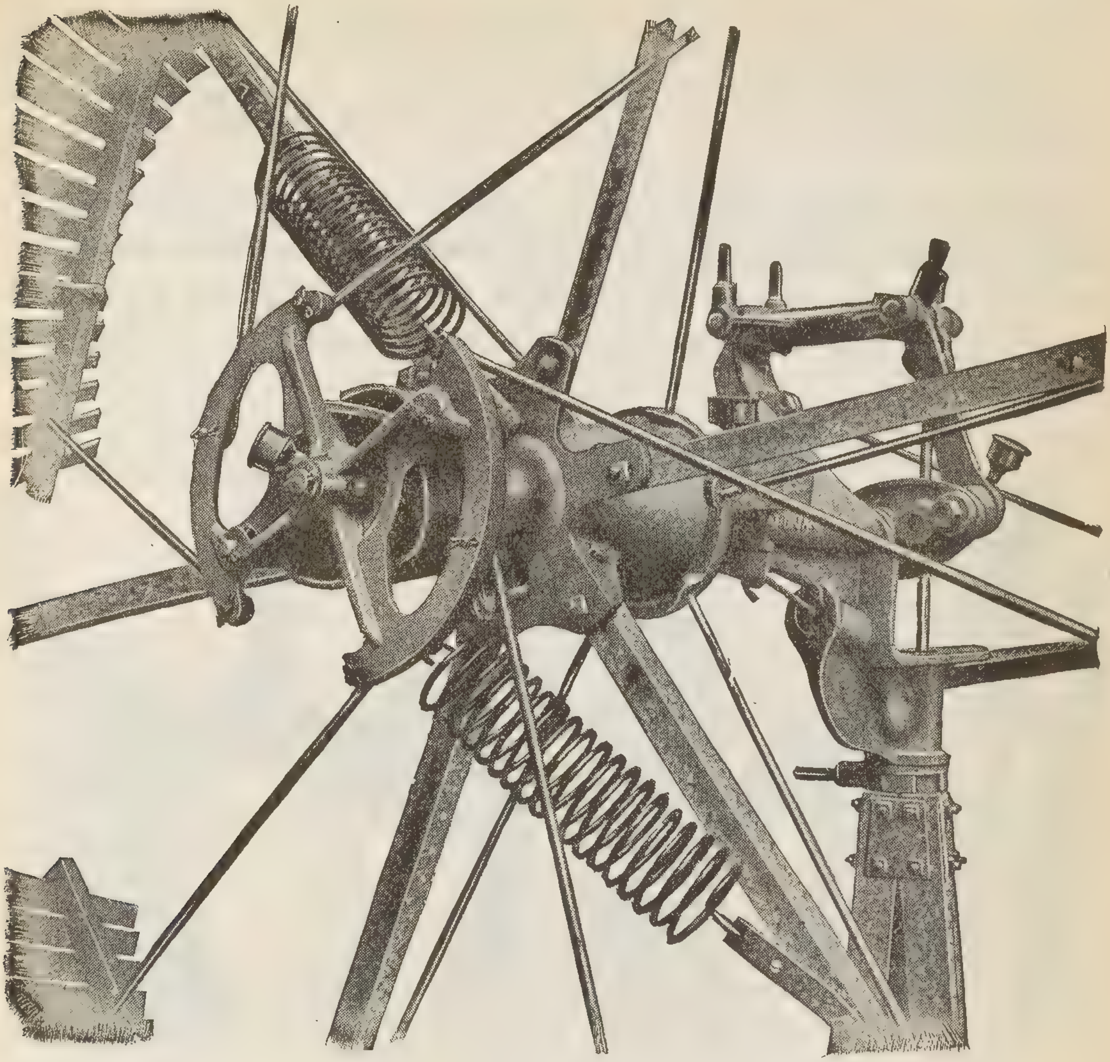
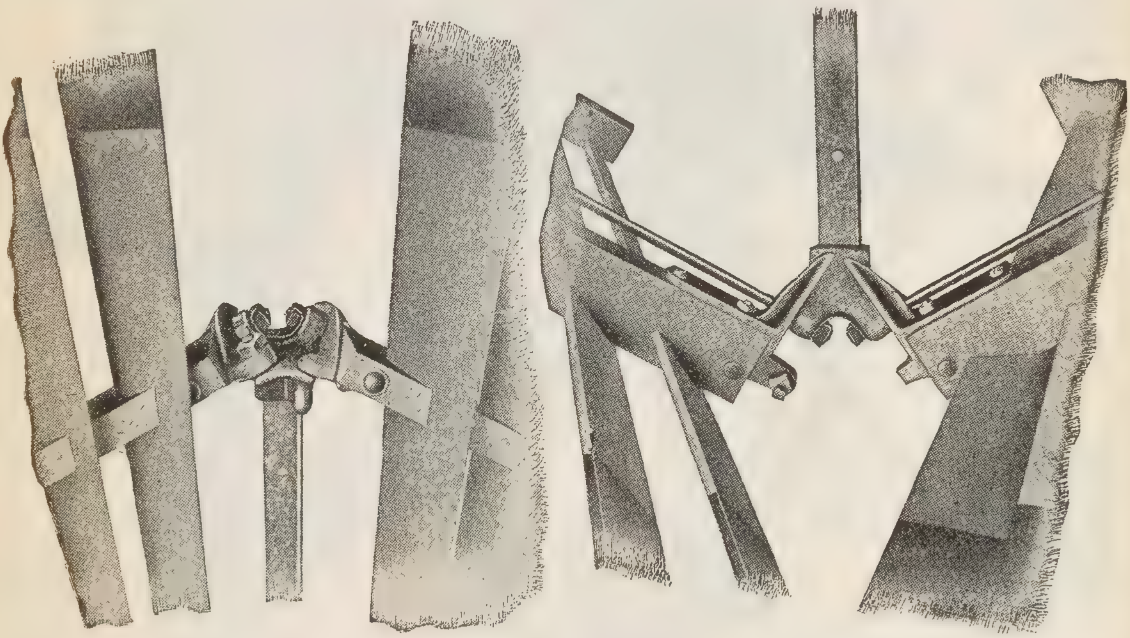


FIG. 8,789.—Monitor vaneless wind mill showing governing mechanism. The shipper spider oscillates on the wheel shaft; the object of this arrangement is to reduce friction and make the governing action more sensitive to changes in the velocity of the wind. In winds above fourteen miles per hour, the speed of the wheel (likewise the speed of the pump) is practically constant. A gust of wind has little effect on it for the increased centrifugal force due to a small increase in the speed of the wheel quickly turns the sections farther out of the wind reducing the effective sail surface.

NOTE.—***Wind mills*** are erected to be operated by the lightest winds. A wind which will carry off smoke will move a wind mill; and the absence of a wind of this force means a perfect calm. ***Mr. Corcoran says:*** "My experience of thirty years teaches that a calm has seldom, if ever, held sway in this part of the world for a longer period than three days. Consequently, with a tank to hold a three days' supply, it becomes possible to pass over any number of calms."

suffice to do a large quantity of work and no storage capacity would be required, but when it does blow it is "free" and experience dictates that a mill shall be erected sufficiently large to pump enough water, when the wind does blow, to last over, with the assistance of ample storage capacity.

Power of Wind Mills.—The power of a wind mill depends on: 1, the diameter of the wheel; 2, area and number of vanes; and 3, velocity of the wind. The following tables give some useful data relating to the sizes and capacities of pumping wind mills.



FIGS. 8,790 and 8,791.—Monitor vaneless wind mill wheel section pivots. Fig. 8,790, section joint with sections in the wind; fig. 8,791, section joint with sections out of the wind.

Table I gives the horse power of several sizes of mills working in a fifteen mile wind: if the wind velocity be increased or diminished, the power of the wind mill will increase or decrease in the ratio of the squares of the velocity. Table V will show the comparative power or force of the wind in velocities from eight to forty miles per hour for each square foot of surface.

Rules for approximately determining size of wind mill to use.—In approximately determining the size of wind mills for a given installation, the daily water consumption must be given as a basis for calculation. *Divide daily consumption by 8 to find hourly capacity of the mill, and if properly loaded the mill will pump on an average eight hours daily.*

TABLE I.

Size of Pumping Mill	6	8	9	10	12	14	16	20
No. Gals. water raised 1 ft. hourly, 15-mile wind	10,000	20,000	24,000	35,000	68,000	110,000	160,000	300,000

TABLE II.

Average wind velocity, miles per hour..................	4	5	6	7	8	9	10	11	12	13	14	15
Co-efficient	16	8	5	3	2	1.4	1.	.85	.70	.60	.54	.50

TABLE III.

Gallons hourly....	.35	170	220	260	300	360	420	550	850	1200	2200	3400	5000
Cylinder, diam. in.	2	2¼	2½	2¾	3	3¼	3½	4	5	6	8	10	12
Discharge pipe, diam. in.	1½	1¼	1¼	1½	1½	2	2	2	2½	2½	3½	4	5

TABLE IV.

COMPARATIVE POWER OF BACK-GEARED MILLS.								
Size of Mill........	4-ft.	6-ft.	8-ft.	9-ft.	10-ft.	12-ft.	14-ft.	16-ft.
Horse-Power	$\frac{1}{12}$	$\frac{1}{5}$	$\frac{3}{10}$	$\frac{2}{5}$	$\frac{3}{5}$	1	$1\frac{3}{5}$	$2\frac{2}{5}$

TABLE V.

FORCE OF THE WIND IN POUNDS PRESSURE.								
Velocity......Miles	8	10	12	15	20	25	30	40
Force.......Pounds	⅓	½	¾	1	2	3	4½	8

TABLE VI.

POWER OF THE WIND.			
Velocity per Hour.	Pressure per Sq. Foot.	Velocity per Hour.	Pressure per Sq. Foot
10 Miles	½ Lb.	20 Miles	2 Lbs.
15 "	1 "	25 "	3 "

Table I gives the maker's number of the pumping mill, and the number of gallons each will raise one foot high per hour, with a wind having a velocity of fifteen miles per hour.

FIG. 8,792.—Demptser so-called vaneless wind mill showing wheel out of wind.

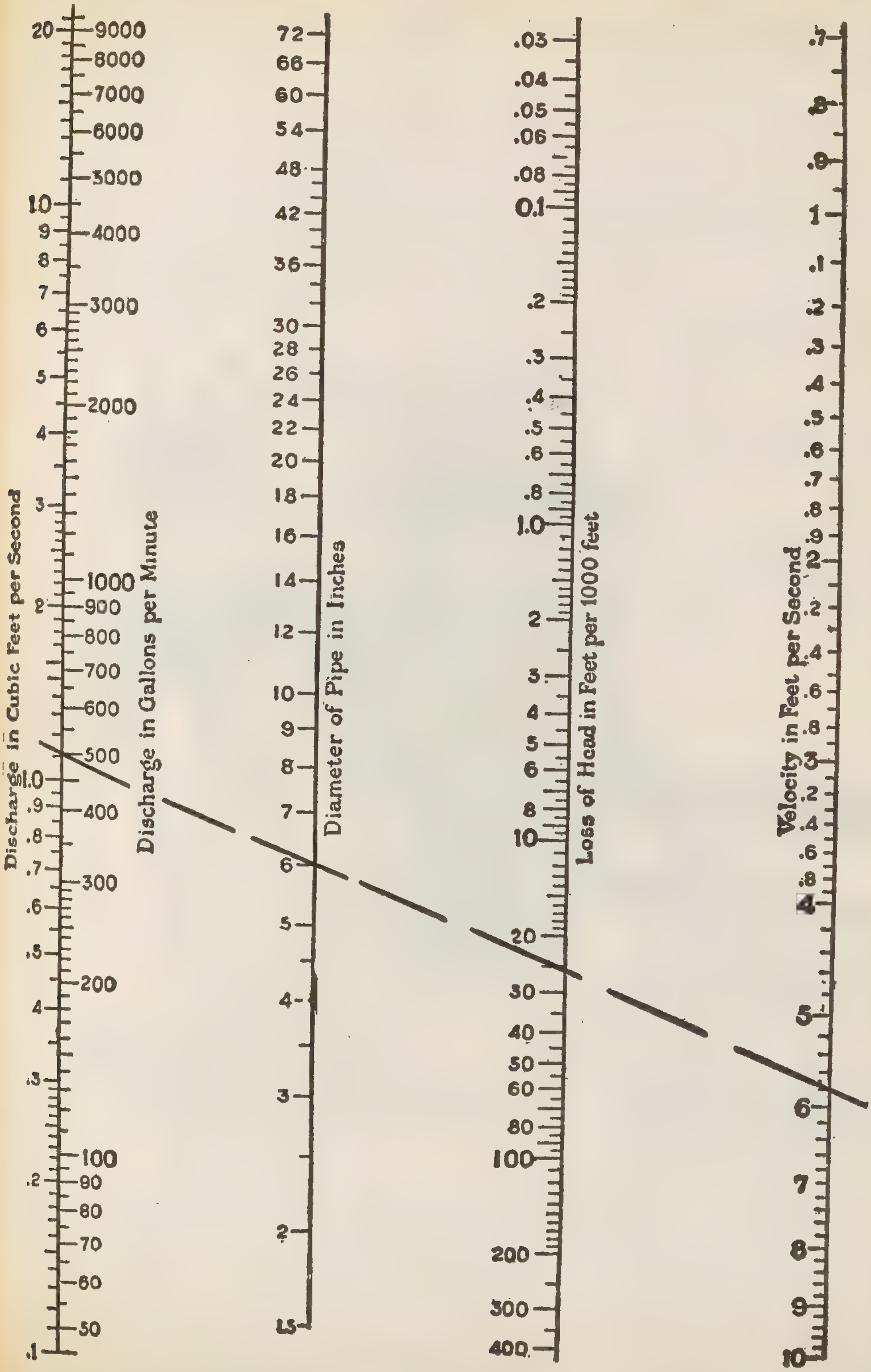


FIG. 8,793.—Diagram for calculating pipe sizes, discharge velocities and loss of head in water pipe. Lay a straight edge on scales at the points for any two known quantities and the unknown quantities will lie at the intersection of the straight edge with the other scales. *Example.*—To discharge 500 gals. per minute through a 6 in. pipe following the dotted line would show a loss of head 1,000 ft. of approximately 25 ft. head and a velocity of 5.8 ft. per second.

Rule.*—Multiply the quotient by total water lift in feet and with the coefficient given in Table II.*

The product will in Table I show what mill to use. The size of the cylinder and discharge pipe will be found in Table III.

Example.—No. 9 pump will raise 24,000 gallons of water one foot high in one hour. Now if the water is to be raised 50 feet then by dividing 24,000 by 50 the quantity raised becomes 480 gallons per hour.

From Table V it will be seen also that a wind velocity of fifteen miles per hour develops a power three times as great as an eight mile wind,

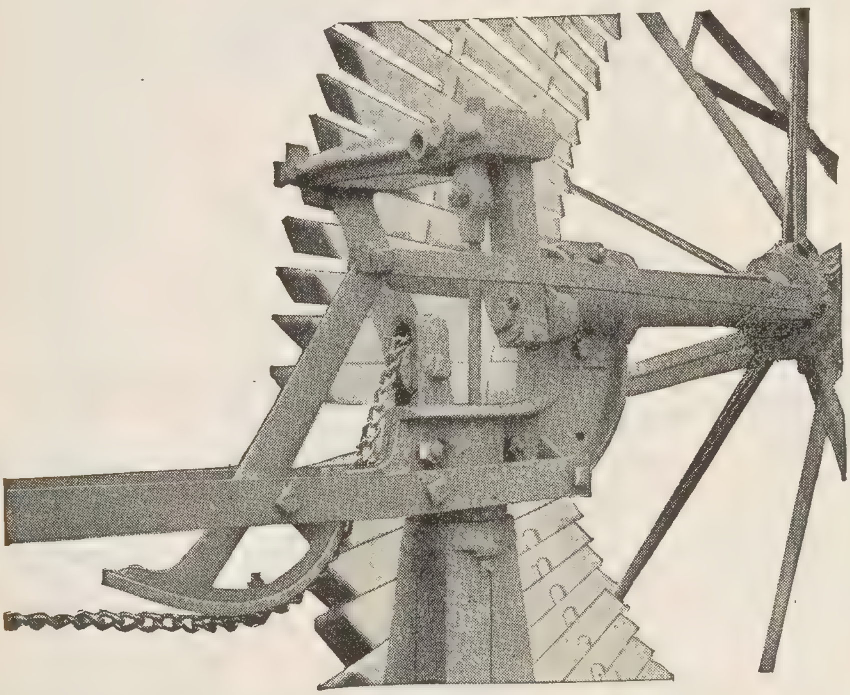


FIG. 8,794.—Challenge vaneless wind mill showing wheel in the wind.

and a twenty mile wind is twice as powerful as a fifteen mile, or six times that of an eight mile wind. Hence, *a small increase in velocity greatly increases the power of the wind mill,* while a low velocity gives but little working force.

From Table VI it is seen that a twenty five mile wind gives six times as much power as a ten mile wind, but really gives twenty-six times *the net efficient power of the ten mile wind,* therefore it will not be proper to calculate on using a power wind mill in as low a velocity as ten miles.

From Table VII it is seen that the net efficient result is six times as great in a fifteen mile wind as in a ten mile wind, and sixteen times greater in

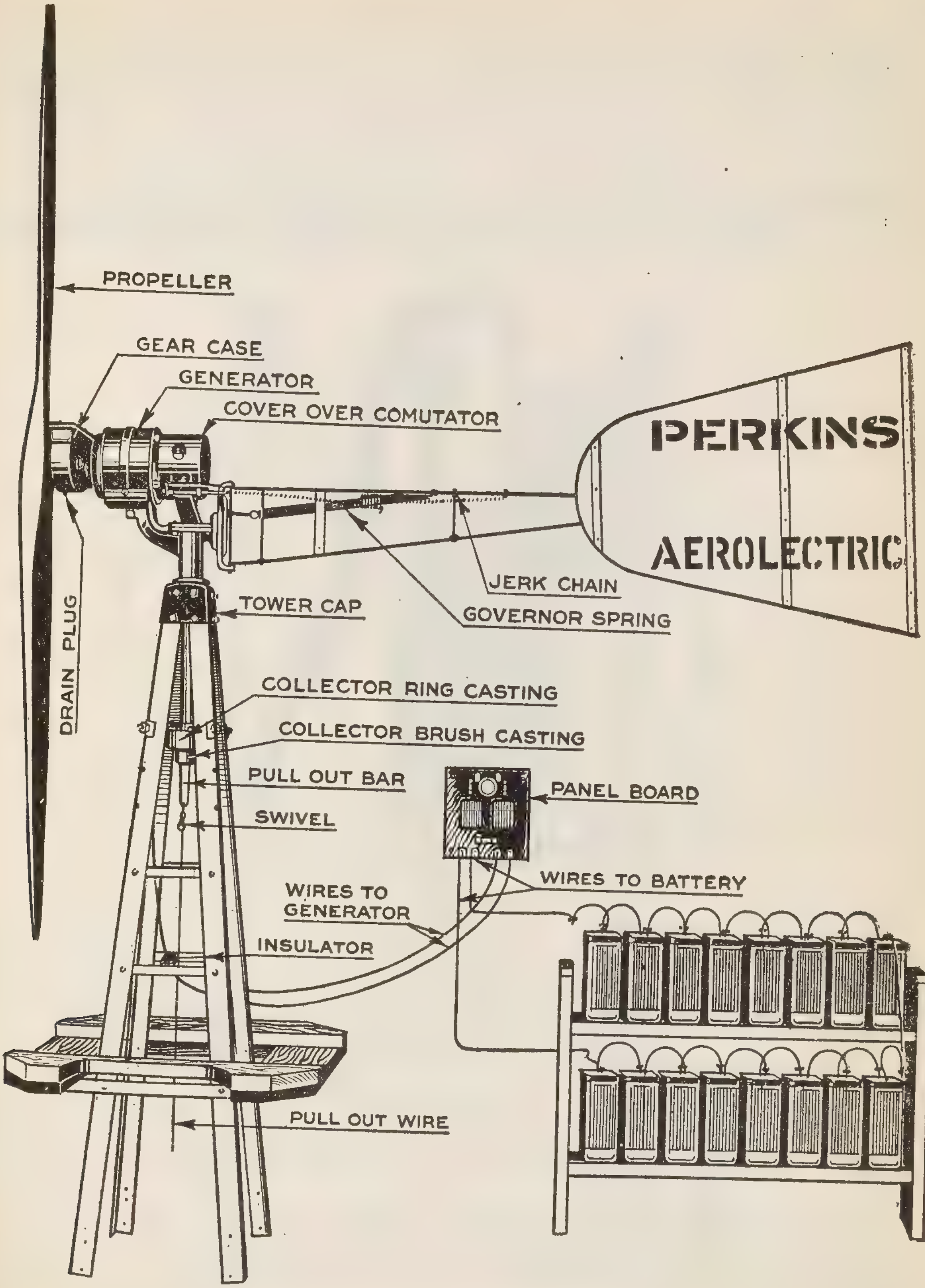


FIG. 8,795.—Aerolectric generating mechanism with gear case cover removed, showing transmission between wheel and dynamo. This is a wind mill suitably geared to a dynamo forming a unit for charging a storage battery, the latter being used as current source for house lighting.

a twenty-mile wind than in a ten mile wind. Therefore, *power wind mills give best results when working in fifteen to twenty-five mile winds.* A 12 foot power wind mill working in a fifteen mile wind will do more work than an average horse, and when working in a twenty mile wind will do more work than two average horses.

Example.—A person in Atlanta, Ga., uses 2,600 gallons of water daily. He has a well in which the water stands 30 feet from ground level.

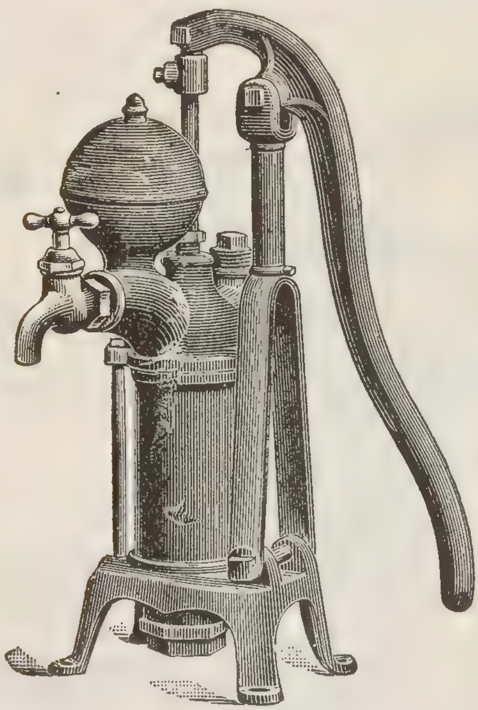


FIG. 8,796.—House force pump. This type is adapted chiefly to kitchen use where water can be supplied from the spout or forced through back outlet to any height above, by closing spout with shut off. It may also be used on drive wells or for a spray pump. The pump is very powerful and will maintain a high pressure as the air chamber is large. It has a seamless brass tube cylinder body, and brass stuffing box nut in top for plunger rod.

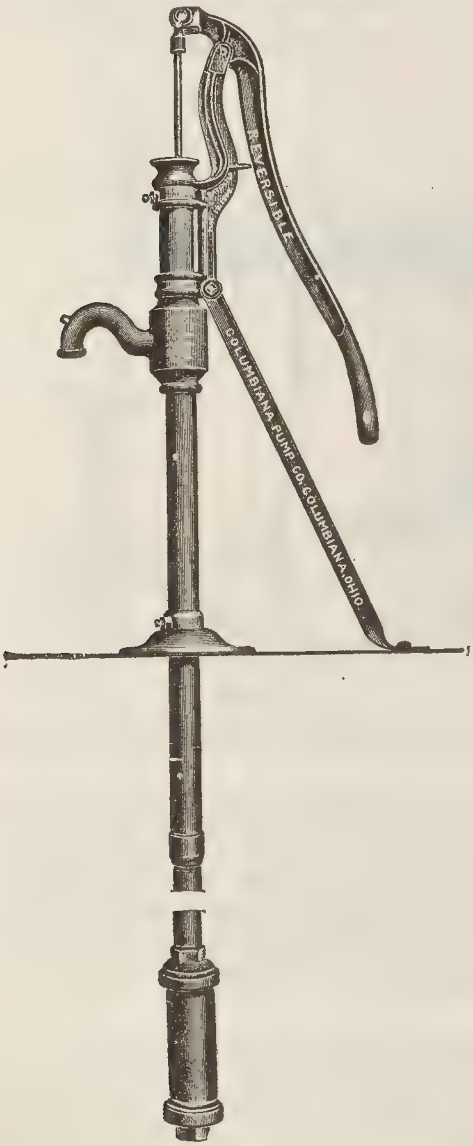
To obtain pressure, the water is to be elevated into a tank 50 feet above ground. $2,600 \div 8 = 325$ gallons to be pumped hourly when wind mill works.

Average wind velocity at Atlanta is 9 miles per hour, answering to coefficient 1.4 in Table II, and total water lift is $30+50=80$ feet. $325 \times 1.4 \times 80 = 36,400$ gallons.

If first estimate of 2,600 gallons daily were liberal, so that for instance 2,400 gallons would be sufficient, Table I shows that a 10-foot mill can be

used, but to keep on the safe side, choose a 12-foot mill. 325 gallons hourly corresponds in Table III, to 3¼ inches cylinder with 2 inches discharge pipe as proper sizes. If the 10 foot mill be chosen, take the 3 inch cylinder.

A 14 foot wind mill working in a fifteen mile wind will do more work than two average horses, and when working in a twenty mile wind will do more work than four good horses, while in a twenty five mile wind it will do more work than six good horses.



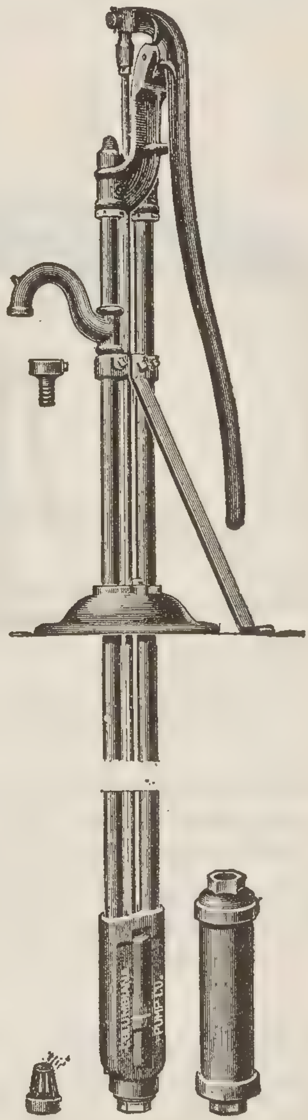


Fig. 8,797.—"Rex" deep well lift pump open or closed top.

Figs. 8,798 to 8,801.—New Fountain deep well double acting force pump.

Wind Mill Pumps.—This type of pump has an extension of the piston rod above the upper guide with a hole for connection with the pump rod from the wind mill. Such a pump with a *pitman* extending from the pump upward into the tower to the mill is shown in fig. 8,802.

This figure is introduced to show the tank connections with a regulator on the base of a four post tower. The float in the water tank throws the mill in or out of gear according as the water rises or falls in the tank.

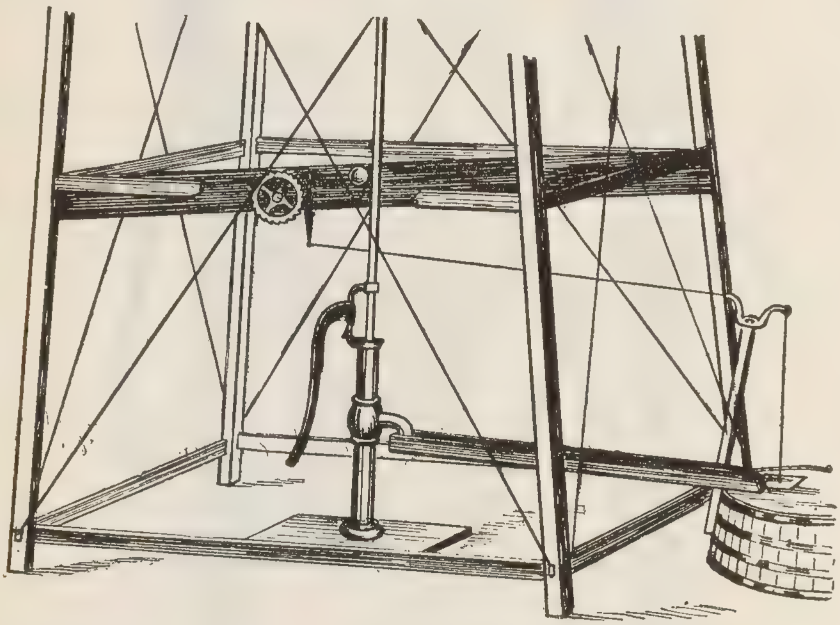


FIG. 8,802.—Base of wind mill tower showing connection with pump and automatic cutoff.

When the tank is filled with water it pulls the mill out of gear and stops the pump; as a result there can be no overflow or waste. The tank is thus not allowed to become empty and permit its drying apart, inducing leakage. Through the medium of a float in the tank, when the water has been lowered but a few inches, the mill is again put in gear and the tank refilled to the desired height, at which the float is set.

The syphon type pump is used to force water from shallow wells to elevations. The cylinder or barrel is placed within the standard and is always primed.

Where the distance from water level in well to ground level

is over say 20 ft., the pump should be lowered to bring the lift within this limit; that is, the suction valve on pump should not be over 20 ft. elevation from the water level in the well.

In cases where pump cannot be lowered conveniently, a deep well pump should be used.

Fig. 8,804 is an example where pump was lowered to bring lift within limit. In this case a deep well pump could not be used as the wind mill

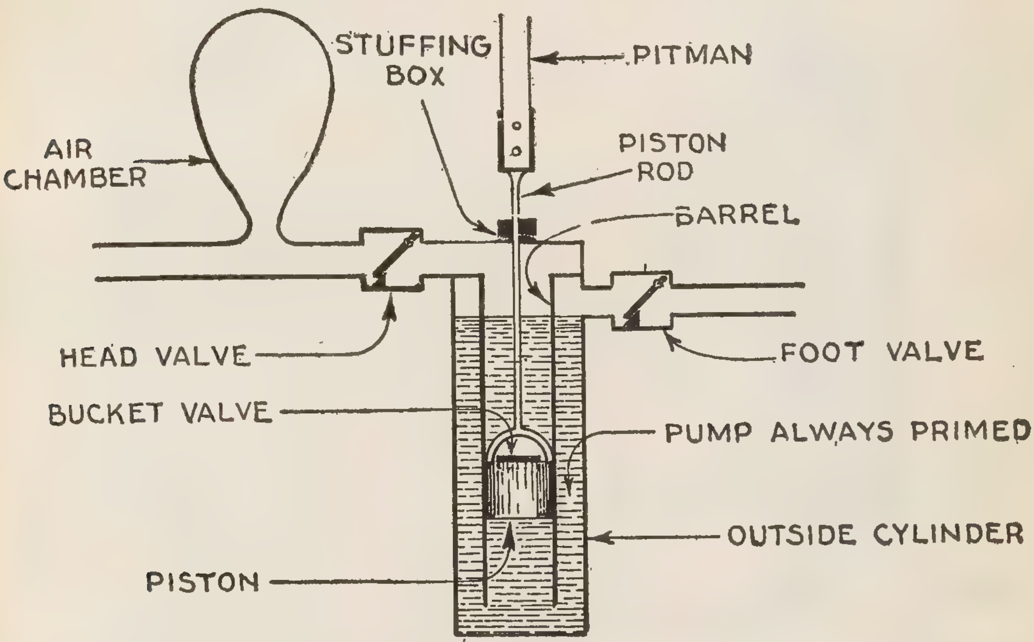


FIG. 8,803.—Elementary so called syphon pump showing pump barrel projecting down into a concentric or outside cylinder providing an annular space which traps water so that the pump is always primed. Anyone having any experience with pumps, especially old and worn pumps, will appreciate this feature.

tower could not be placed over well. Where a deep well is located directly under wind mill tower a deep well pump is used, as in fig. 8,805, thus avoiding the necessity of digging a separate pump pit.

The plumber should understand the construction of the various types of pumps as shown in the accompanying illustrations in order to properly make repairs.

Power Pumps.—The term *power pumps* ordinarily signifies a pump by belt, gears or other transmission receiving its power from some external source. They are usually classified according to the number of cylinders, as:

1. Single
2. Duplex
3. Triplex
4. Quadruplex, etc.

Evidently, a belt or gear transmission between the pump

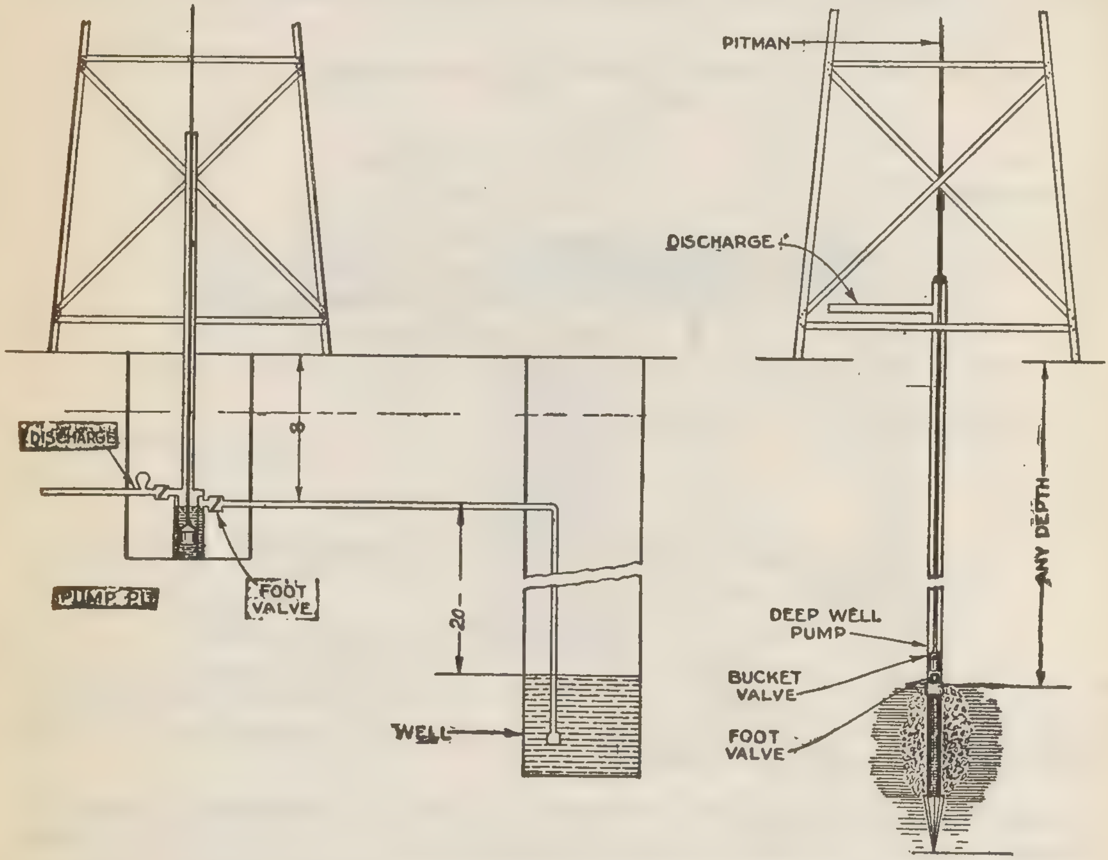


FIG. 8,804 and 8,805.—Pump connections at residence of the author at ***Stornoway***, near Sea Bright, N. J., illustrating location of pump in pit to reduce lift to practical limit. As shown in fig. 8,804 the well was about 50 ft. from the tower and the arrangement of buildings prevented placing wind mill tower directly over well, otherwise a deep well pump would have been installed, as shown in fig. 8,805.

and power unit will permit any velocity ratio; thus when the pump for instance is connected to a steam engine by belt as in fig. 8,806, by proper selection of pulley sizes the pump

may be driven at a low speed with engine running at relatively high speed, which is desirable for economy of steam. Moreover, any degree of economy may be obtained according to the type of engine selected.

The accompanying illustrations show power pumps operated by various power drives; these illustrations also show the construction.

Points Relating to Pumps.—1. The necessary parts of a

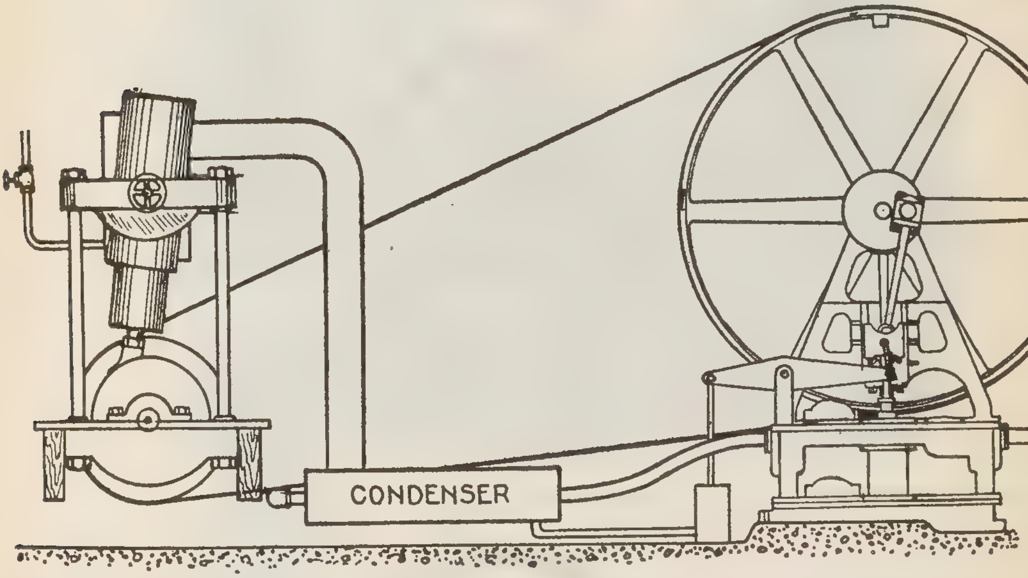


FIG. 8,806.—Graham jacketted, transfer expansion oscillating engine, and Dunham power pump with belt transmission. ***It must be evident*** that this arrangement permits the engine and pump to work under the most favorable conditions for economy. Hence by proper proportion of pulleys, the engine may run at ***high speed,*** thus reducing the size of the cylinder and loss by condensation, leakage, etc., and the pump may be run at ***slow speed,*** thus reducing the loss by slip, and eliminating water hammer, slamming of valves, etc.

pump are the cylinder, the plunger, or the piston with its bucket valve, the lower check valve (or foot valve), the suction pipe, and the piston rod and connecting rod. In order that the pump work properly, all of these parts should be in perfect condition. The cylinder should be true, the piston (or plunger) should fit the cylinder accurately, and the check valves should set square and tight.

2. Theoretically, water can be raised by suction about 33 feet; but as it is impossible to obtain a perfect vaccuum, 25 to 28 feet is as great a vertical distance as is safe to recommend placing a pump or cylinder above the water to insure its successful operation. In fact, the nearer the cylinder is to the water, the more probable it is to work at all times, and when practical the cylinder should be submerged.

3. Suction pipes should be short and as straight as possible, with few or no valves, elbows and fittings, and arranged to have no "pockets"

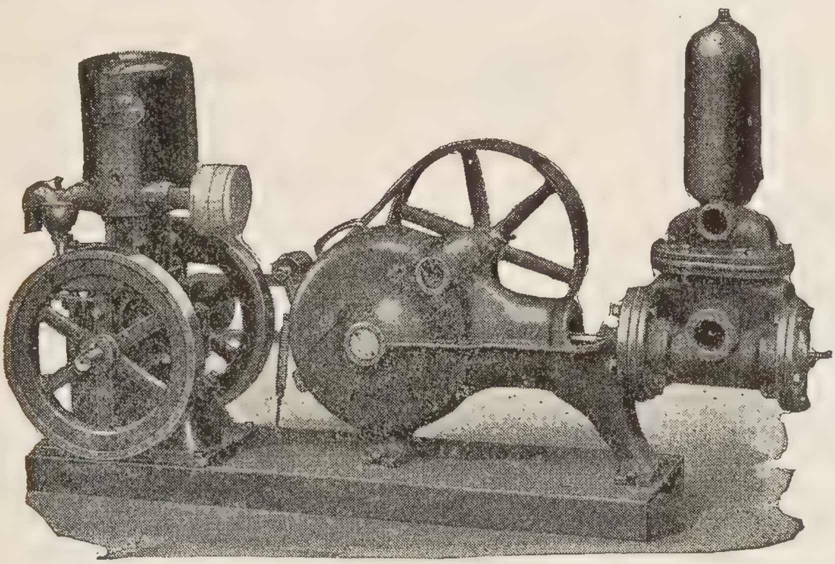


FIG. 8,807.—Leader-Trahern geared power pump belted to gas engine.

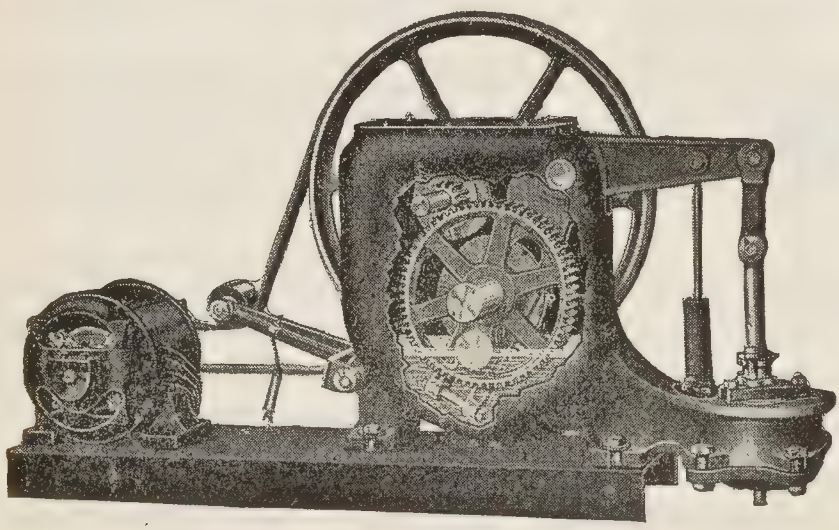
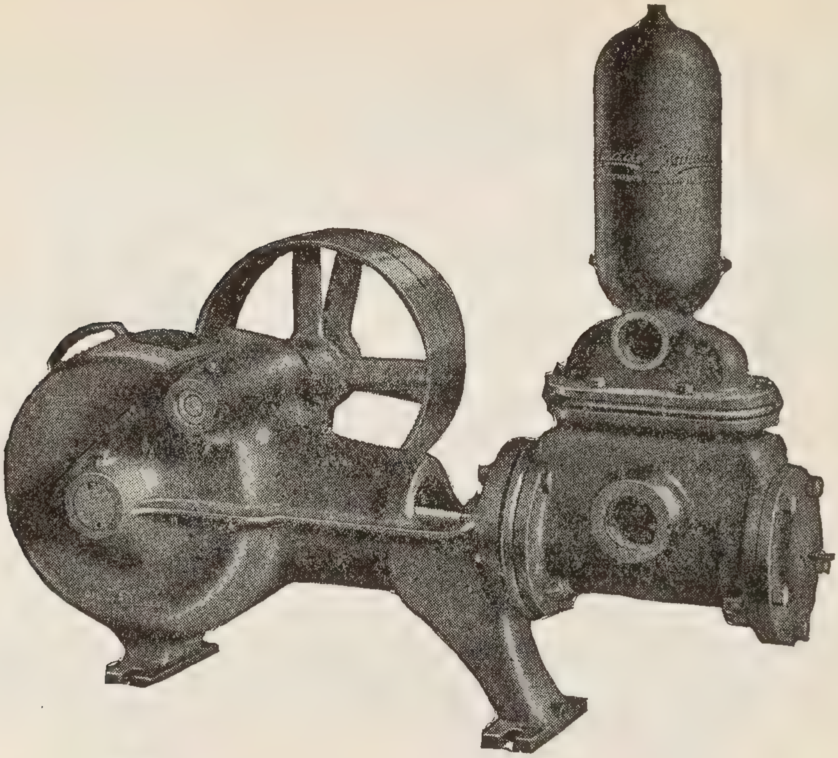
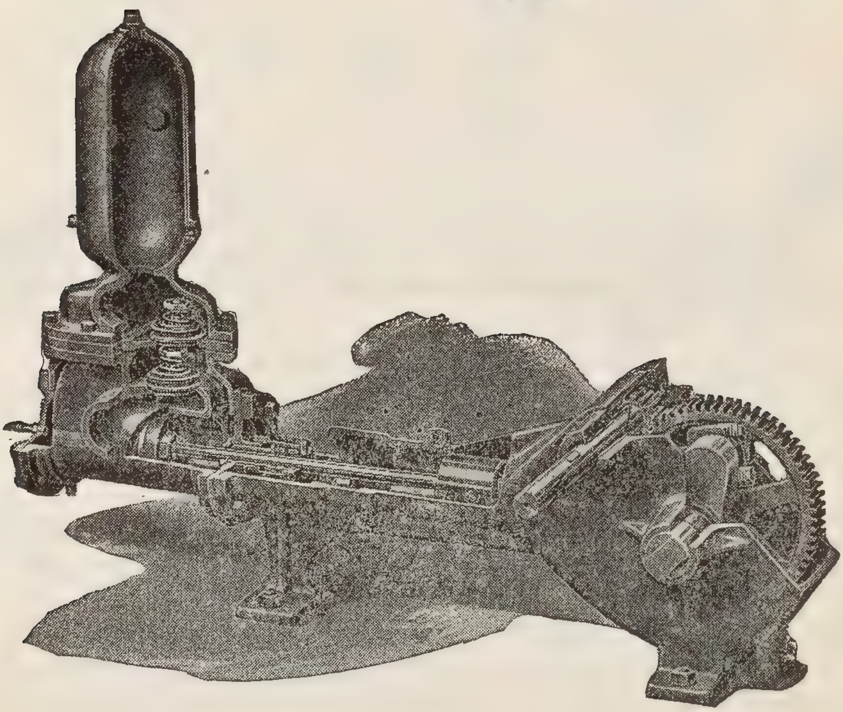


FIG. 8,808.—Leader-Trahern geared deep well power pump belted to electric motor; sectional view showing gears and oil bath.





Figs. 8,809 and 8,810.—Leader-Trahern geared power pump with light and loose pulley for drive off jack shaft. All working parts are enclosed and run in an oil bath.

where air can collect. Long suctions or high lifts should always have a vacuum chamber at the pump and a foot valve should be used, the area of which should be as great as the pipe. The suction pipe below the cylinder should not be longer than one length of pipe—from one to sixteen feet.

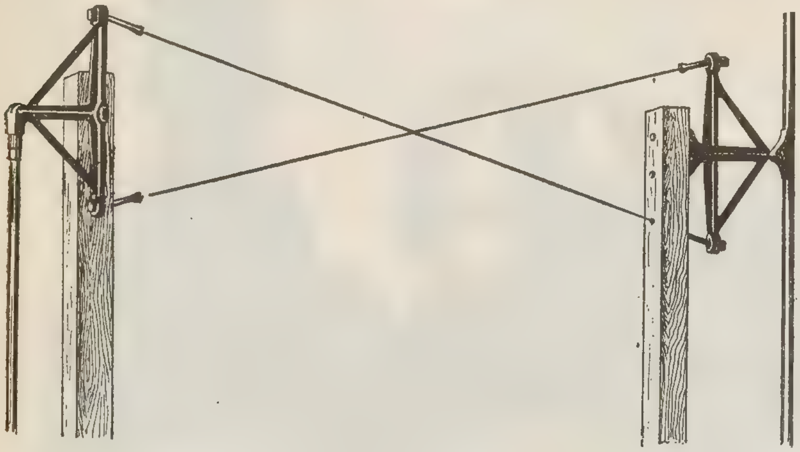


FIG. 8,811.—Butler triangles for transmitting motion of mill rod to pump when mill is located a distance from the pump. Connecting wires should always be crossed so the mill rod and pump plunger will work in unison, and the windmill will do the heavy work on up stroke.

FIG. 8,812.—Butler rocker shaft for transmitting wind mill rod movement to pump when about 20 feet or less from tower. Always set arms on shaft so the mill and pump make the up stroke at the same time. To do this it will be necessary to have arms both on same side of shaft, as shown in cut.

4. Every part of the cylinder or suction pipe should be absolutely air-tight, for a very slight leakage will reduce the capacity of pump greatly; sometimes altogether.

5. No mud, sand, gravel, or other foreign substances should enter the suction pipe or cylinder, and in case of such danger a strainer should be used and the total area of strainer holes should be from three to five times the area of pipe.

6. Discharge pipes should be as large and as straight as possible, to

avoid loss of power in overcoming friction. A hole about the size of a knitting needle must be made in pipe below line of frost, to prevent freezing.

7. Serious mistakes are often made in trying to economize by using pipe too small for cylinder, causing the pump to work unsatisfactorily, and then all the blame is placed on the wind mill. Both suction and discharge pipes should never be less than two-thirds the size of the cylinder and if pipe as large as cylinder be used, the results will be more satisfactory. One-inch pipe should never be used in any depth of well; the plunger rod and couplings alone nearly choke up 1-inch pipe and will not permit free discharge of water, even though a small cylinder is used.

8. A general plan adopted in getting the length of pipe, valve rods, suction pipe, etc., after having determined depth of well, is first to adjust the whole by laying pipe, rods, cylinder, etc., on the ground and so fit the whole that when put together it will be the proper length.

9. In wind mill pump standards or other pumps where stuffing boxes are used, it is most important to see that the stuffing box is not too tightly packed. This fault is most common and many times these stuffing boxes are so tightly packed that it is an impossibility to move the plunger rod. And often, when the rod can be moved, it does so at a tremendous loss of

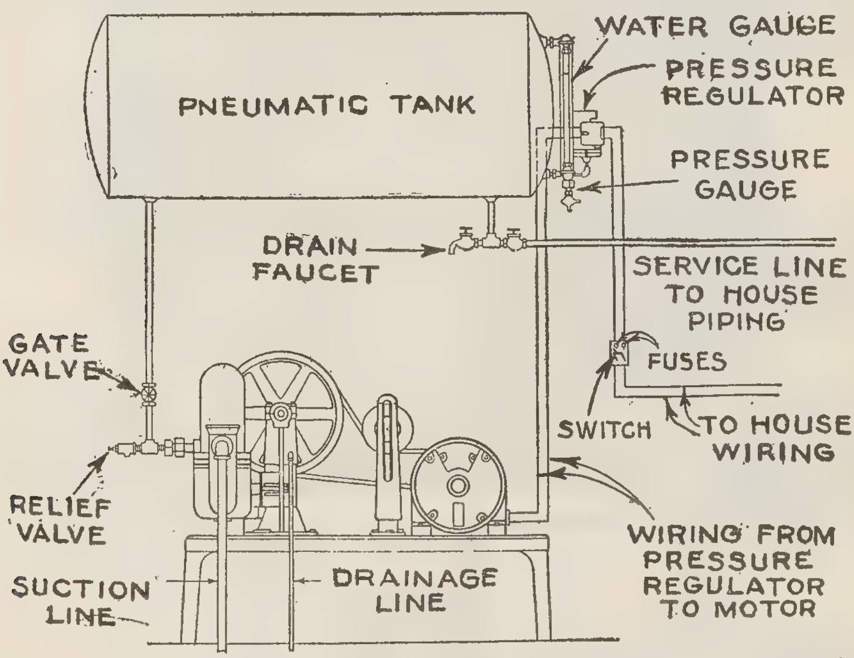
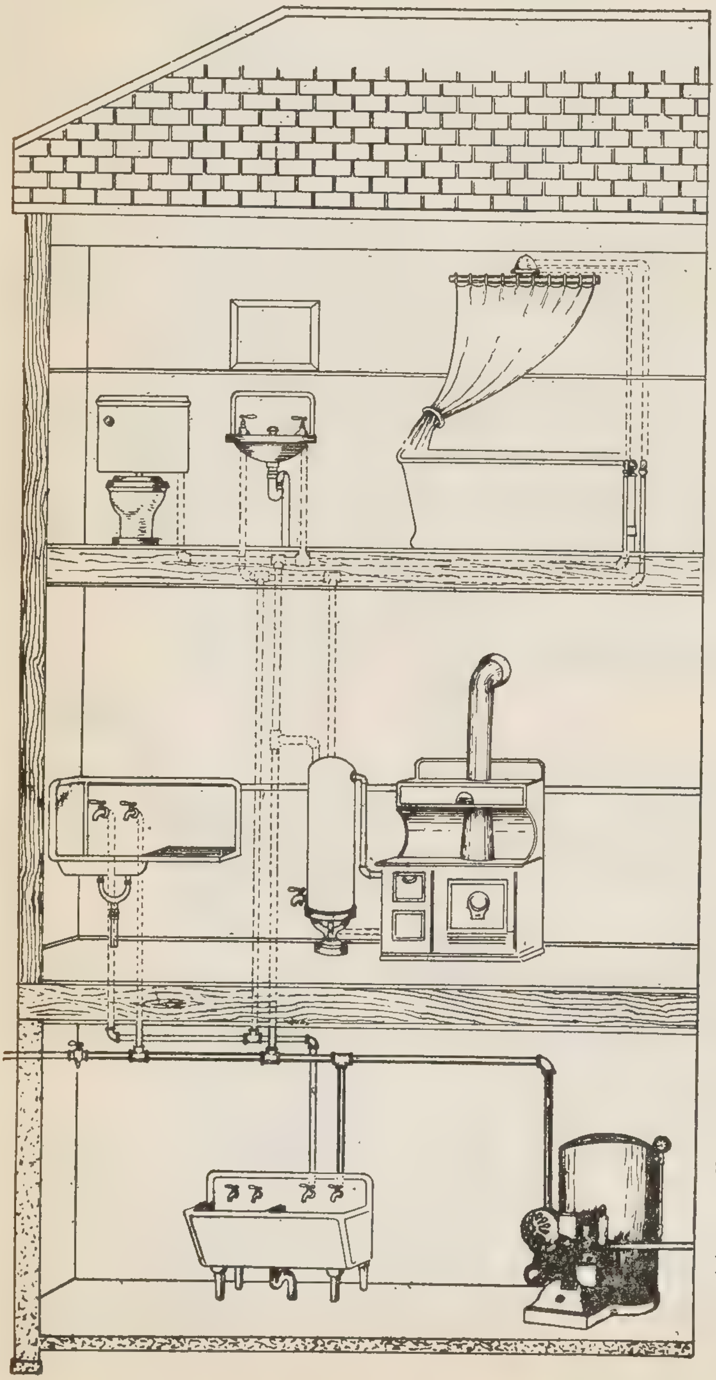


Fig. 8,813.—Goulds automatic pneumatic water pumping system showing typical piping and wiring connections for use with pneumatic tanks when installed either on the floor back of pumping outfit, along side or overhead. Wherever the construction of the tank allows, it is recommended that it be set vertically. The pressure regulator and pressure gauge are attached to the lower gauge fitting. This installation is recommended for locations where there is limited space. Both the tank and pump should be installed in the basement or other place where they will be protected from freezing temperature.

power due to friction, the result being that the wind mill is not working half of the time that it would if the stuffing box were properly packed.



Pneumatic System.—This system furnishes a supply of water for house requirements, forcing it to the upper floors without the necessity of providing an elevated tank.

Fig. 8,814 shows the details of the system and the principle is very simple. An air-tight steel tank is put in basement of house, and the mill pumps air and water into the tank, thus compressing the air in it. This compressed air furnishes the power to distribute the water.

When the air is compressed to a predetermined certain number of pounds pressure, the back pressure operates the diaphragm controller, which works the regulator, and the mill is pulled out of gear and stops pumping.

FIG. 8,814. — Fairbanks-Morse automatic pneumatic water pumping system showing piping and connections to fixtures in residence.

When sufficient water is drawn to reduce the pressure inside the tank to a given degree, the mill is put back into gear, and starts pumping again, putting more air and water into the tank for further use.

Electric motor or gas engine power may also be used instead of the wind mill. The pneumatic system should not be confused with the Pohle air lift method of pumping water.

Tanks.—To insure an ample supply of water at all times a storage tank of ample capacity is necessary. In order to obtain

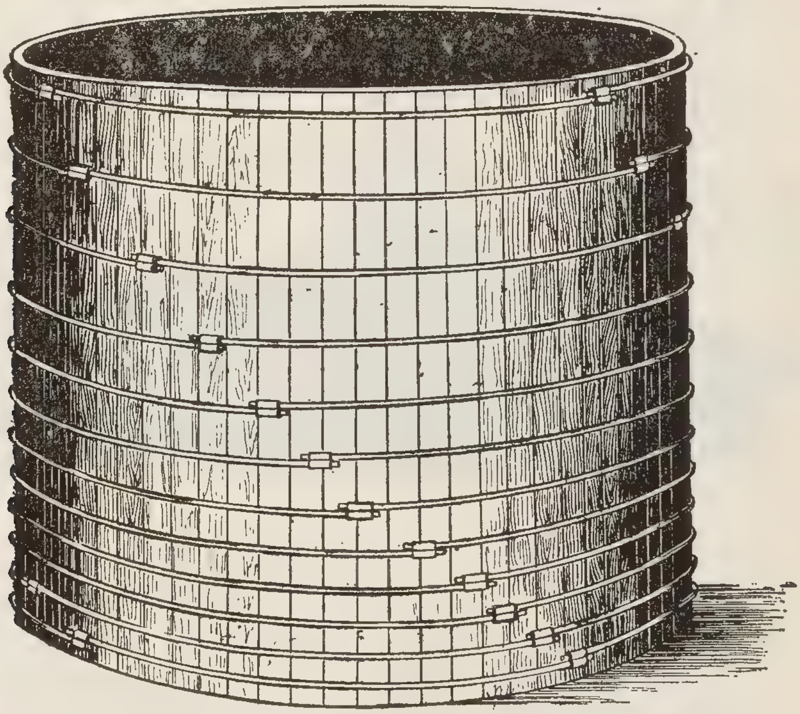


FIG. 8,815.—Cylindrical wind mill tank showing staves and retaining steel hoops.

sufficient pressure to force the water from the highest outlet the bottom of the tank should be higher than the highest outlet.

Tanks are made of various woods, as cedar, cypress, fir, redwood, etc., and also of sheet steel and cast iron. If the tank is to be used the year round and is located where it cannot be fully protected from freezing, a wooden tank is best. The capacity of a tank should be sufficient to hold a three days

supply to guard against calms, the duration of which according to A. J. Corcoran practically never exceeds three days.

The capacity of tanks is usually measured in terms of gallons or barrels of 31½ gallons each. One manufacturer lists tanks of wood or galvanized steel to hold 8, 20, 40, or 80 barrels and states further that the 20 barrel tank and the larger sizes, may be used with either the 8, 10, 12 or 14 ft. wheel, the 8 barrel tank being suitable for only very small requirements.

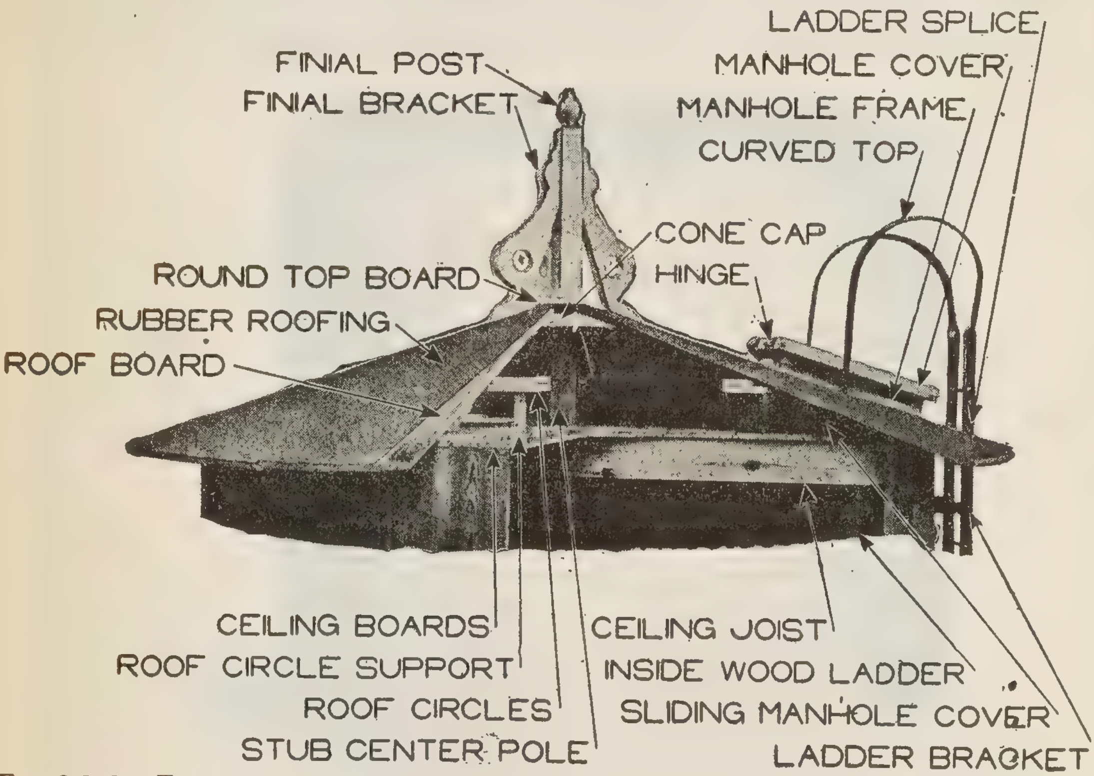


FIG. 8,816.—Tower and tank showing foundation.

Example.—A wind mill is to be erected for a daily consumption of 1,000 gals. Find dimensions of *a* cylindrical tank, and *b*, tapered tank of three day capacity.

capacity =3 ×1,000 =3,000 gals. or 3,000 ÷31½ =95.2 barrels. Say 95 barrels.

Case 1. Cylindrical Tank.

The first problem is to determine diameter of bottom. This is limited by the size of tower at proposed elevation of tank and should correspond to proportion (diameter and height) adopted by manufacturers. The following table shows the proportions of tanks as manufactured by Butler.

Properties of Tanks

(Type illustrated in fig. 8,815)

Length Staves Feet	Diameter of Bottom Feet	Number of Hoops	Capacity in Barrels	Approximate Weight Lbs. 2-in. Cypress
4	4	4	9.	326
4	5	4	14.9	428
4	6	4	22.	538
4	8	4	40.2	786
5	5	5	19.	500
5	6	5	28.	640
5	7	5	37.	775
6	6	5	34.6	737
6	7	5	46.	900
6	8	5	62.5	1078
6	10	5	98.	1493
7	6	6	40.	840
7	7	6	54.	1008
7	8	6	73.	1215
8	6	7	45.9	940
8	8	7	84.	1353
8	10	7	133.	1895
8	12	7	193.6	2440
10	4	8	24.2	726
10	6	8	58.	1139
10	8	8	106.	1626
10	10	8	168.	2253
10	12	8	245.	2855
10	14	8	327.5	3285
12	12	10	281.5	3330
12	14	10	387.6	3860
14	12	12	336.9	3690
14	14	12	455.	4437

It is seen in the table that tanks may be obtained in several diameters for each length of stave. Assume tower to be large enough for an 8 ft. (diameter) tank then

area bottom $= \text{diam.}^2 \times .7854 = 8^2 \times .7854 = 50.27$ sq. ft.

3,000 gals. $= 3{,}000 \times .13368 = 401.04$ cu. ft.

This reduction can also be obtained without calculation from the following table:

Cubic Feet in a given Number of Gallons.

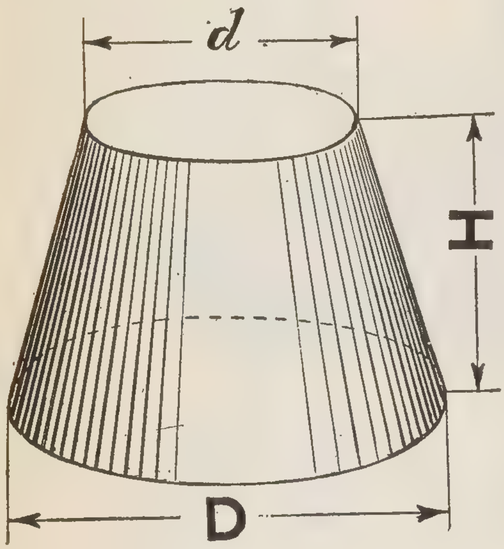
Gallons.	Cubic Ft.	Gallons.	Cubic Ft.	Gallons.	Cubic Ft.
1	.134	1,000	133.681	1,000,000	133,680.6
2	.267	2,000	267.361	2,000,000	267,361.1
3	.401	3,000	401.042	3,000,000	401,041.7
4	.535	4,000	534.722	4,000,000	534,722.2
5	.668	5,000	668.403	5,000,000	668,402.8
6	.802	6,000	802.083	6,000,000	802,083.3
7	.936	7,000	935.764	7,000,000	935,763.9
8	1.069	8,000	1,069.444	8,000,000	1,069,444.4
9	1.203	9,000	1,203.125	9,000,000	1,203,125.0
10	1.337	10,000	1,336.806	10,000,000	1,336,805.6

Rule.—*To obtain height of tank divide capacity in cu. ft. by area of bottom in sq. ft.*

Height of tank =401.04 ÷50.27 =7.8 ft. By inspection of the table the nearest stock height is 8 ft. hence make size tank 10 ft. diam. ×8 ft. high.

Case 2. Tapered Tank.

Example.—Find height of a tapered tank of 3,000 gals. capacity having a bottom 8 ft. in diameter and top 6 ft. diameter.



$$\text{VOLUME} = D^2 + d^2 + (D \times d) \times .7854 \, \frac{H}{3}$$

$$H = \frac{3 \times \text{VOLUME}}{D^2 + d^2 + (D \times d) \times .7854}$$

FIG. 8,817.—Frustum of a cone illustrating shape of tapered tank with formulæ for calculation of volume and height. D, diameter of bottom; *d*, diameter of top; H, height.

Rule.—*Divide three times the volume corresponding to capacity by the sum of the squares of both diameters plus the product of both diameters multiplied by* .7854.

Value as obtained in case 1 is 401.04 cu. ft.

$$\text{height of tank} = \frac{3 \times 401.04}{8^2 + 6^2 + (8 \times 6) \times .7854} = 10.4 \text{ ft.}$$

In comparing Case 1 and Case 2 note difference in height of tapered tank due to taper.

Approved method of construction of wooden tanks according to Kidder are given in the following notes:

Staves and Bottom of tanks of greater capacities than 15,000 gal. should be made of 2½ in. dressed to about 2¼ in. stock for tanks 12 ft. and not exceeding 16 ft. diameter or 16 ft. deep. For larger tanks 3 in. dressed to about 2¾ in. stock should be used. For smaller tanks 2 in stock may be used. Staves should be connected about one-third the distance from the top by a ⅝ in. dowel to hold them in position during erection. The bottom planks should be dressed on four sides, and the edges of each plank should be bored with holes not over 3 ft. apart for ⅝ in. dowels.

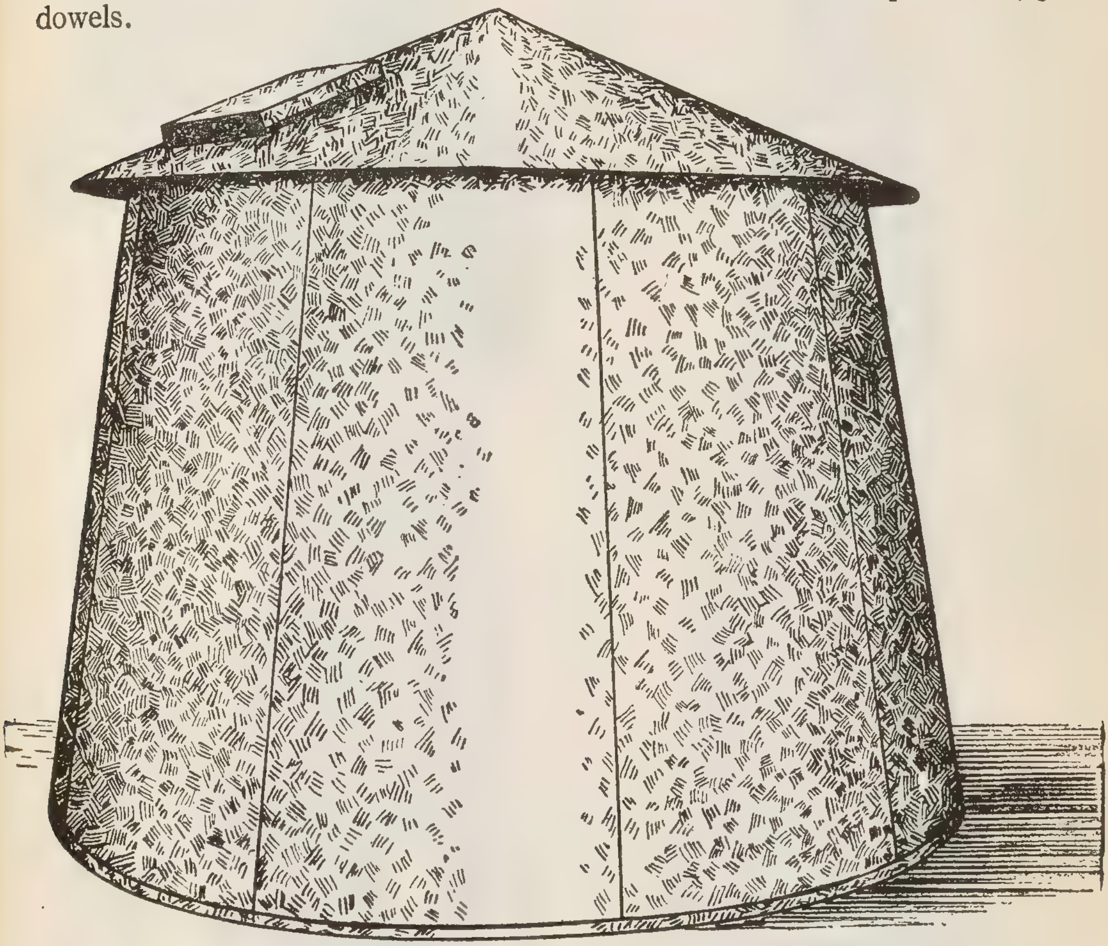


FIG. 8,818.—Tapered steel tower tank.

Taper.—The batter to each side should not be less than ¼ in. nor more than ½ in. per ft.

Hoops should be of wrought iron or mild steel of goood quality. Wrought iron is preferable because it does not rust as easily as steel. There should be no welds in any of the hoops. Where more than one length of iron is

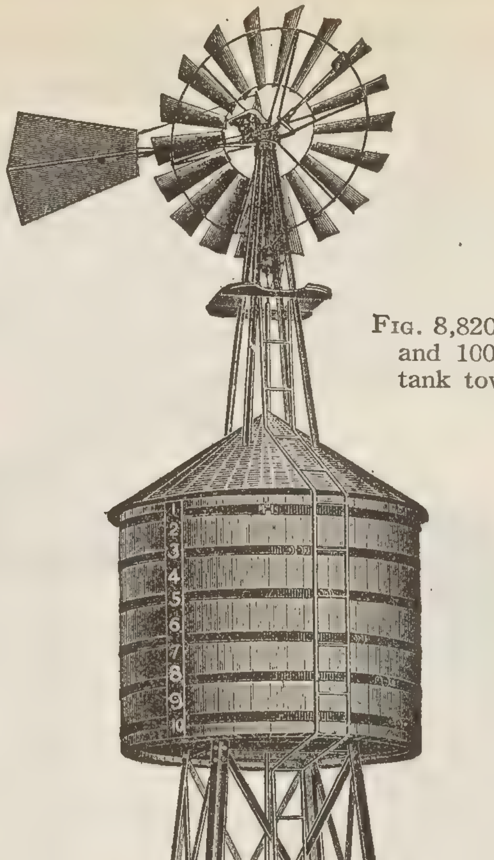


FIG. 8,820.—Wind mill and 100 barrel steel tank tower.

FIG. 8,819.—Superior wind mill and 70 barrel tank steel tower. ***In construction,*** heavy wrought iron bolts go from the sills into the stone or concrete piers, at the end of which lower anchors are also furnished to go on the lower end of the bolts.

necessary, lugs should be used to make the joints; and when more than one piece is necessary the several pieces constituting one hoop should be tied together in preparing for shipment.

Hoops for fire tanks should be of such size and spacing that the stress in no hoop will exceed 12,500 lbs. per sq. in. when computed from the area at root of thread. For general purposes a stress of 15,000 lbs. per sq. in. is permissible. On account of the swelling of the bottom planks, the hoops near the bottom may be subjected to a stress greater than that due to the water pressure alone; additional hoops, therefore should be provided.

For tanks up to 20 ft. in diameter, one hoop of the size used next above it should be placed around the bottom opposite the croze and not counted upon as withstanding any water pressure. For tanks 20 ft. or more in diameter, two hoops, as above, should be used. Hoops with upset ends must not be used.

FIG. 8,821.—One hundred barrel tank steel tower with platform and railing erected on galvanized steel substructure, the bottom of tank being 20 ft. from the ground. The total weight of tank when filled with water, 33,000 lbs. (without the wind mill tower and mill) so that it is absolutely necessary to have a strong reliable substructure to carry so great a weight. Great care should be taken in erecting outfits of this kind to see and know that the foundations for same (which should be made of stone piers) are deep enough in the ground to prevent heaving by frost, and that each pier has a large base to safely carry the weight placed on them.

The top hoop should be placed within 2 in. of the top of staves, so that the overflow pipe may be inserted as high as possible.

Hoops should be so placed that the lugs will not be in a vertical line. No hoop should be less than ¾ in. in diameter. All should be cleaned of mill scale and rust and painted one coat of red lead, lampblack and boiled oil before erecting.

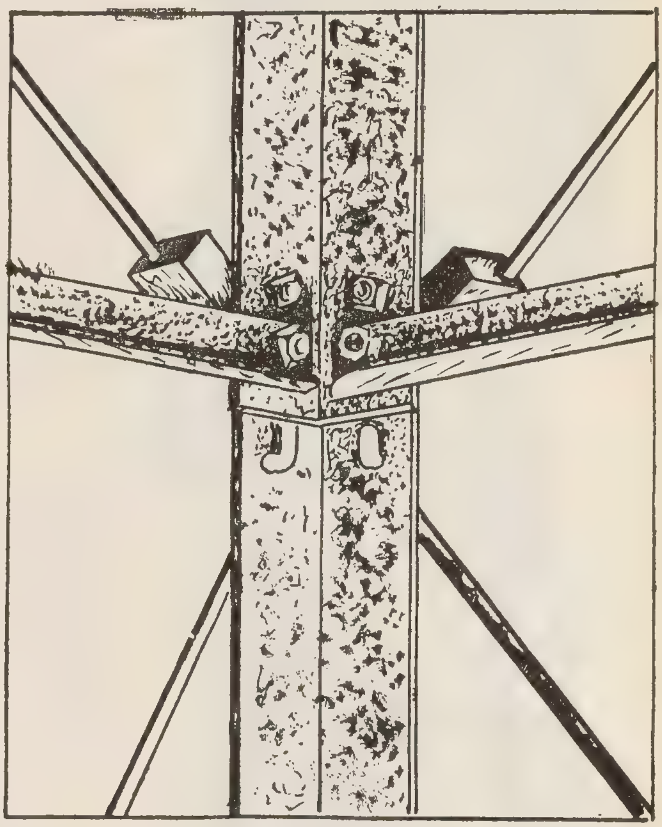


FIG. 8,822.—Butler steel tower construction 1. Brace rod.

FIG. 8,823.—Butler steel tower construction 2. Internal view of tower where bands and braces intersect corner post. ***In construction,*** the lower ends of the braces are hooked into corner posts of tower. This relieves the bolts and bands from double duty. When the brace rods are put through the bands not only is a large hole punched through the band, which greatly weakens it, but the strain brought on it by trying to put a tension on brace rod buckles the bands, which draws in the corner posts, making it impossible to put a tension on rods, which leaves the whole structure loose and weakened. Nearly everything depends on the brace rods being drawn tightly. Remove or loosen the brace rods on any steel tower and it will collapse in a comparatively light wind.

NOTE.—The strength of a tank depends chiefly on its hoops. Round hoops are specified because they do not rust rapidly; a slight amount of rust does not have the same weakening effect as on a flat hoop, and round hoops are not likely to burst when the tank swells, as they will sink into the wood.

Spacing of Hoops.—The hoops should be spaced so that each one will have the same stress per sq. in. and no space should be greater than 21 ins. To meet this requirement the hoops must be spaced quite close together at the bottom, the space between them gradually increasing toward the top.

Support.—The weight of the tank should be supported entirely from its bottom; and in no event should any weight come on the bottom of the staves. The planks upon which the tank bottom rests should cover at

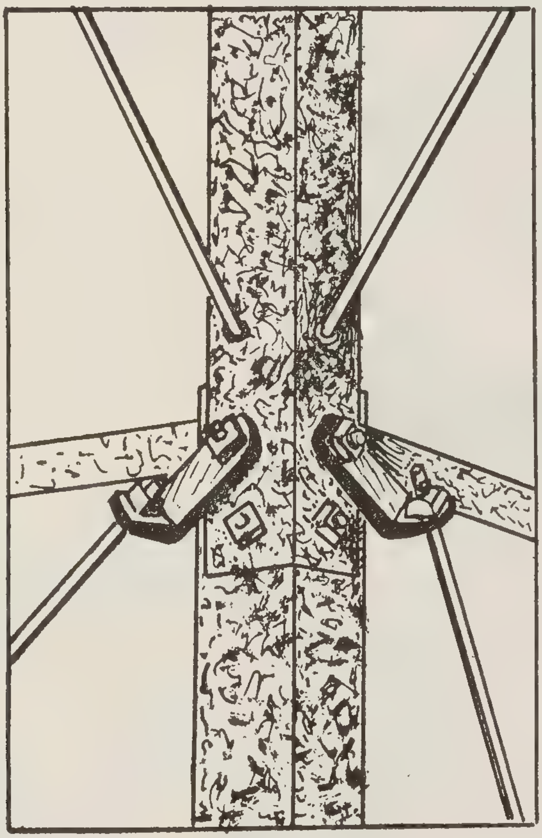


Fig. 8,824.—Butler steel tower construction 3. Outside of corner post of tower showing method of attaching brace rods and bands.

least one-fifth the area of the bottom, should not be over 18 in. apart and of such thickness that the bottom of the staves will be at least 1 in. from the floor.

Pipes.—The *discharge pipe* should preferably leave the bottom of the tank at its center and extend up inside of the tank 4 ins. to allow the sediment to collect in the bottom of the tank.

The *overflow pipe* should be placed as near the top of the tank as possible discharging either through side or bottom, as may be desired. An overflow is much to be preferred to a telltale, as the latter is liable to get out of order.

Towers.—In order to insure a direct current of wind for the wind mill the tower used should be high enough to raise the wheel at least twenty feet above trees, buildings or other obstructions within 300 ft. The sole purpose of the tower is to get the wind wheel up away from eddying ground currents, where it will receive a steady wind.

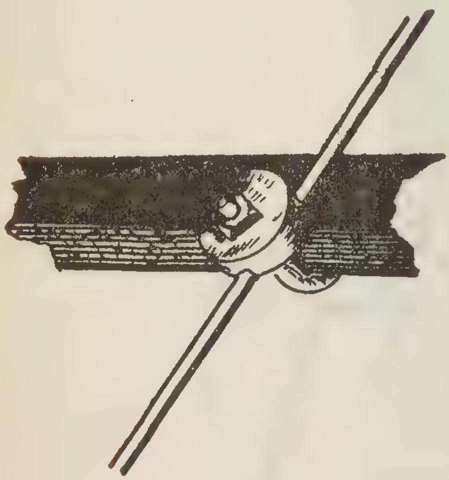


Fig. 8,825.—Butler steel tower construction 4. Brace rod tie, showing method of tying together the brace rods where they cross near bottom of tower. By tightening the nut slightly until the cast washers begin to grip the rods, the washers can be forced up by hammering them moderately on lower side, thus bringing the cross in bottom set of brace rods above one's head, and avoiding the inconvenience of having to stoop when passing in and out from the pump.

Fig. 8,826.—Butler steel tower construction 5. Forged clip for tying brace rod to band without punching hole in band.

Towers are made either of wood or steel, usually with four parts, but sometimes with three parts for small sizes called tripod towers.

The accompanying illustrations show various towers and details of construction.

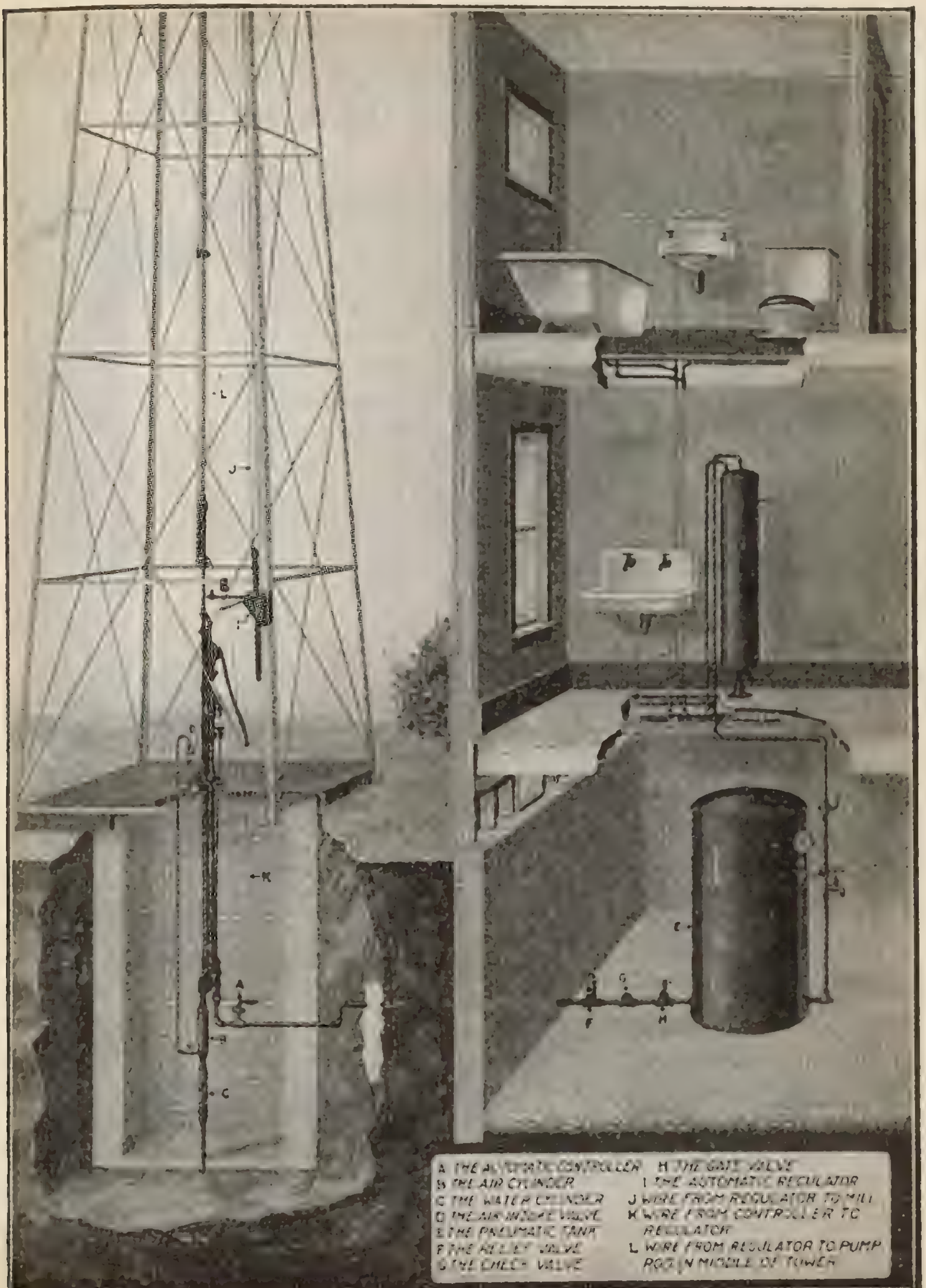
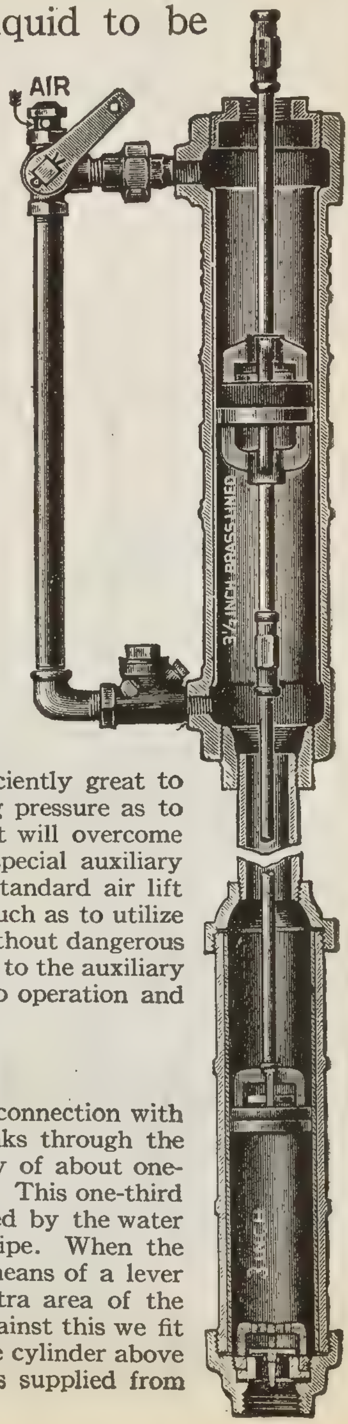


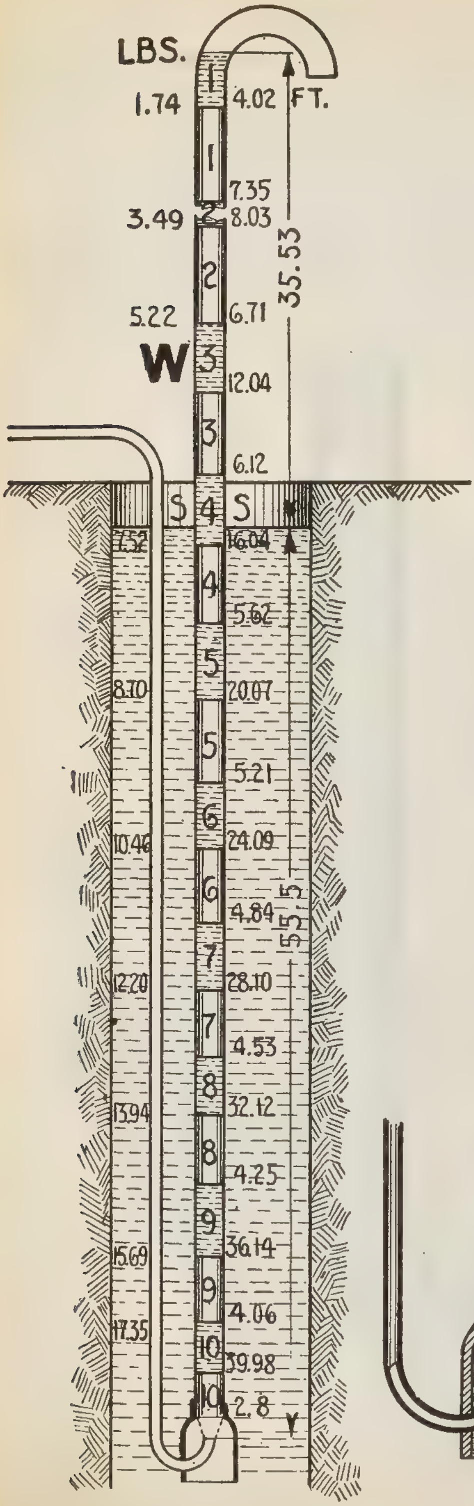
FIG. 8,827.—Butler pneumatic water supply system for wind mill power.

Pohle Air Lift.—This is one of the simplest methods of raising water. The process consists in submerging a portion of an open-ended eduction-pipe in a body of the liquid to be

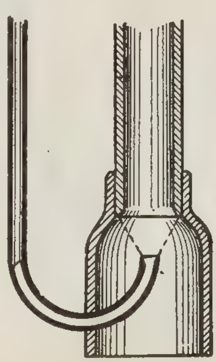


NOTE.—*The total lift* or head enters largely into all calculations for the air lift. Very often the actual pumping level in the well or group of wells is not known, but it is possible to procure fairly accurate information from well drillers' tests, past pumping operations or from the characteristics of wells in the immediate vicinity. From these sources a close determination of the pumping level is made and the well piped accordingly. After the piping is installed and the pumping level ascertained, the piping should be adjusted to obtain the yield best suited to economical operation. This is generally done by raising or lowering the pipe until the proper submergence is established. It is the natural tendency (provided a satisfactory quantity of water is obtained) to let well enough alone, without any consideration for economy of operation. Such a situation ought not to be permitted in a permanent installation, even if necessary to change the sizes of pipe in order to secure the best and most economical results. It is essential that both the discharge and air pipes be properly proportioned as the velocity of flow is the most important factor. If too large a pipe be used, the velocity may be low, and a loss will occur on account of slippage, bubbles of air slipping through the mixture; and on the other hand, if the velocity be too high, there is undue friction loss. The discharge pipe in any air lift should be so designed that the sum of these two losses will be a minimum. In some wells the difference between the static and pumping head may be sufficiently great to make the starting pressure so much higher than the running pressure as to seriously overload the air compressor. The compound air lift will overcome this difficulty. It consists of a standard air lift pump with a special auxiliary or starting pump. This auxiliary pump is placed above the standard air lift pump. Its submergence with respect to the static head is such as to utilize the maximum pressure of which the compressor is capable without dangerous overload. When starting a well, the air is first turned on to the auxiliary pump and as the head lowers, the standard pump comes into operation and the auxiliary pump is gradually turned off.

FIG. 8,828.—Butler hydro-pneumatic cylinder to be used in connection with any force pump head for forcing air into air pressure tanks through the discharge pipe. *In principle,* the cylinder has a capacity of about one-third more area than the water cylinder located below it. This one-third of the capacity of the pneumatic cylinder not being supplied by the water cylinder supplies itself with air taken through the air pipe. When the pump is not required to pump air, it can be shut off by means of a lever extending to the base. When the air is shut off this extra area of the pneumatic cylinder would form a vacuum. To provide against this we fit the cylinder with a bypass taken from the upper part of the cylinder above the plunger, through which bypass this extra requirement is supplied from the discharges.



raised and continuously introducing into the liquid within the lower part of the pipe a series of bubbles of compressed gaseous fluid containing enough of the fluid to expand immediately across the pipe and fill the same from side to side, forming pipe-fitting piston like layers at or just above the point of their entrance into the pipe, whereby the column of liquid rising in the pipe after the forcing out of the liquid first standing in the latter is subdivided by the gaseous fluid into small portions before it reaches the level of the liquid outside of the pipe, and a continuously upward-flowing series of well defined alternate layers of gaseous fluid and short layers of liquid is formed and forced up the pipe.



The figures represent the apparatus in a state of action pumping water, the shaded sections within the eduction pipe W, representing water layers and the intervening blank spaces air layers.

FIGS. 8829 and 8,830.—Diagram of Pohle air lift system showing principle of operation.

At and before the beginning of pumping, the level of the water is the same outside and inside of the discharge pipe W, incidentally, also, in the air pipe. Hence the vertical pressures per square inch are equal at the submerged end of the discharge pipe. When, therefore, compressed air is admitted into the air pipe *a*, it must first expel the incidental standing water before air can enter the eduction pipe W. When this has been accomplished, the air pressure is maintained until the water within the eduction pipe has been forced out, which it will be in one unbroken column, free from air bubbles.

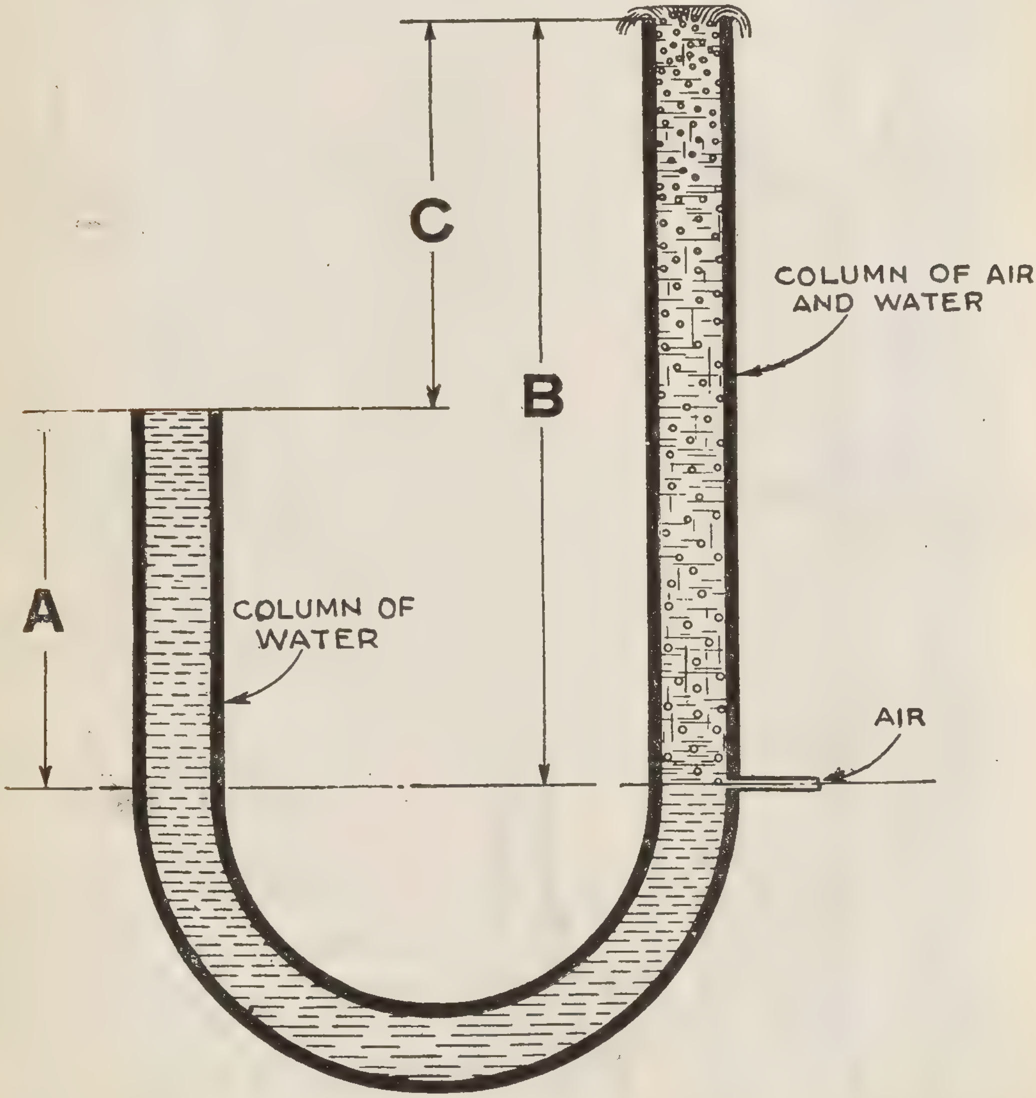


FIG. 8,831.—Principle of air lift. The injection of air at the point indicated produces a column of mixed air and water B, which has less weight than the solid column of water A. Thus the weight of the column A, causes the water to rise the distance C, and overflow.

When this has occurred the pressure of the air is lowered or its bulk diminished and adjusted to a pressure just sufficient to overcome the external water pressure. It is thus adjusted for the performance of regular and uniform work, which will ensue with the inflowing air and water, which adjust themselves automatically in alternate layers or sections of definite lengths and weights. It will be seen in the figures that the lengths of the water columns (shaded) and air (blank spaces) 1 and 1 are entered at the right of the discharge pipe W; also, that under the pressure of two layers of water 1 and 2, the length of the air column 2 is 6.71 feet long, and so on. The lengths of aggregate water columns and the air columns

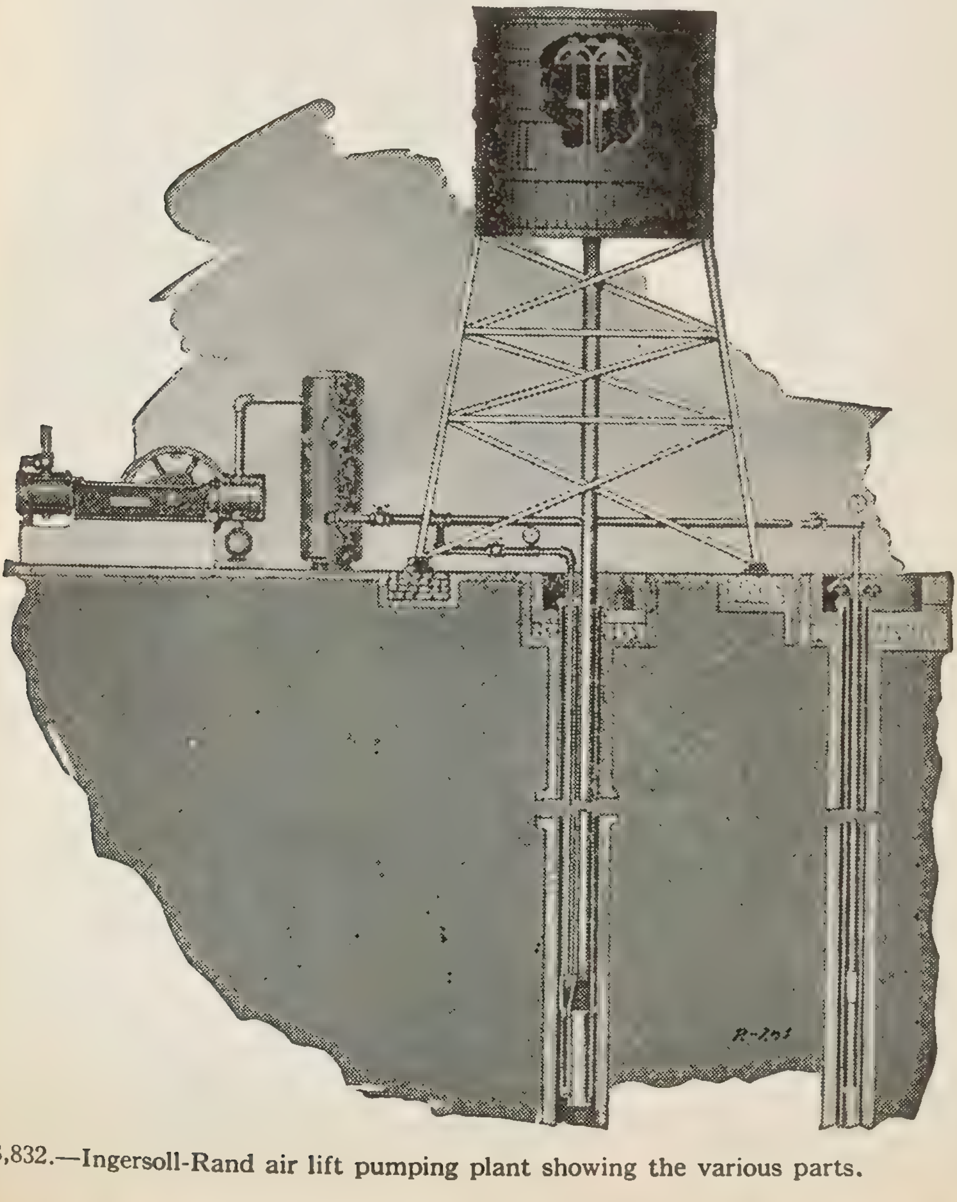


FIG. 8,832.—Ingersoll-Rand air lift pumping plant showing the various parts.

which they respectively compress are also entered on the right of the water pipe.

On the left of the water pipe are entered the pressures per square inch of these water columns or layers. Thus the pressure per sq. in. of column 1 is seen to be 1.74 lbs.; that of 2, consisting of two columns or layers 1 and 2 each 4.02 feet long, to be 3.49 lbs., and that of 10, consisting of nine columns or layers of water 1 to 9, iuclusive, each 4.02 ft. long, and one of 3.80 ft. in length (viz., layer 10) to be 17.35 lbs., and the aggregate length of the layers of water is 39.98 ft. in a total length of 91 feet of pipe.

It will be noted that the length of pipe below the surface of the water

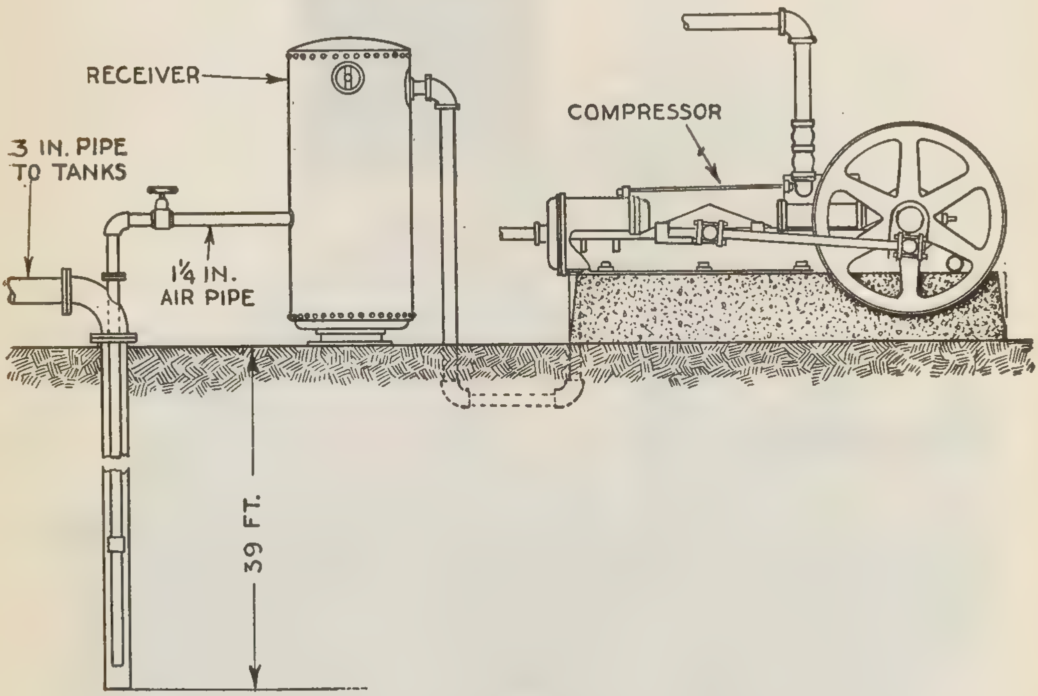
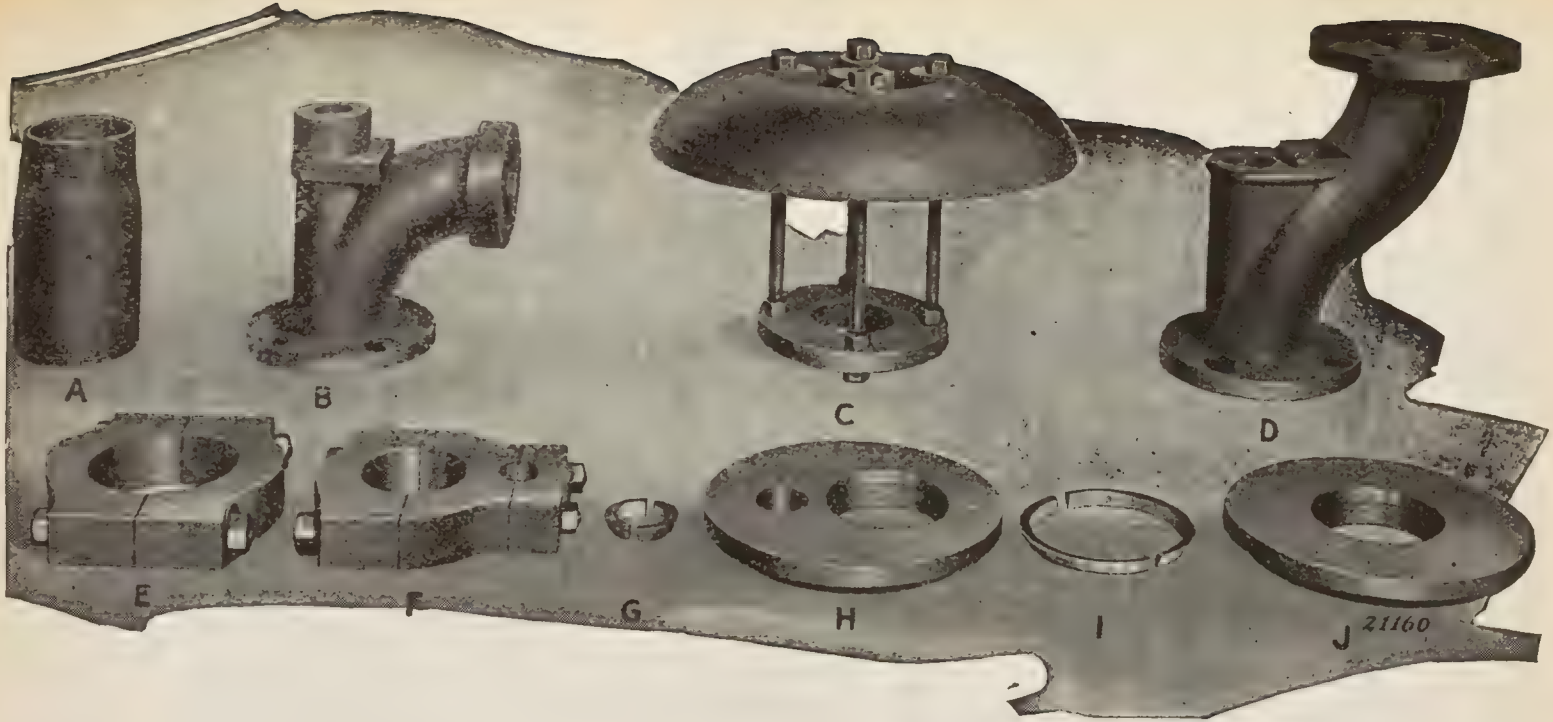


FIG. 8,833.—Pohle air lift plant showing compressor, air tank and connections.

in the well is 55.5 ft., and that the difference between this and the aggregate length of the water layers (39.98) is 15.52 ft. That is, on equal areas the pressure outside of the pipe is greater than the pressure on the inside by the weight due this difference of level, which is 47.65 lbs. for the end of the discharge pipe.

It is this difference of 15.52 ft., acting as a head that supplies the water pipe, which puts the contents of the pipe in motion, and overcomes the resistance in the pipe. In general the water layers are equal each to each, and the pressure upon any layer of air is due to the number of water layers above it.



FIGS. 8,834 to 8,843.—Ingersoll-Rand air lift parts. ***Head piece,*** the preferred type of head piece is the umbrella shaped deflector shown as part C, in the illustration. Deflectors are furnished for both the standard and central air pipe arrangements. Elbow head pieces are also used, and for the central air pipe system the elbow head part B, and the offset type part D, is used. The latter is used where the water is to be raised above the surface. ***Well caps,*** the well cap, parts H and J, is a loose casting, closing the top of the well and forming a support for the piping. This cap is machined to receive a brass packing ring, parts G, and I, around the pipes between the well cap and the supporting clamp. The weight of the pipes on the brass packing ring positively seals the joint with no possibility of leakage. ***Supporting clamps,*** supporting clamps are used for carrying the weight of the water and discharge pipes. These rest on the well cap. With the outside system of piping, this supporting clamp shown part F, is a combination discharge and air pipe clamp holding both the water and discharge pipes above well cap. The supporting clamp for the central air pipe system, part E, differ slightly in that there is but a single clamp, otherwise it is the same as the outside system. ***Long taper nipples,*** the method of using a tapered discharge pipe, increasing in diameter from the foot piece to the point of discharge, calls for a taper nipple, or connecting fitting, between the different sizes of pipe used. This taper nipple is shown as part A,

Thus the pressure upon the bottom layer of air 10 in the figure is due to all the layers of water in the pipe (17.35 lbs.), and the pressure upon the uppermost layer of air 1 is due to the single layer of water 1, at the moment of its discharges beginning, viz., 1.74 lbs. per sq. in. As this discharge progresses this is lessened, until at the completion of the discharge of the water layer the air layer is of the same tension as the normal atmosphere.

The air pipe is connected with an air receiver on the surface, which is at or near the engine room, in which there is *an air compressor*. This air pipe is provided with a valve on the surface. Before turning on the air the conditions in the well show water at the same level on the outside and inside of the eduction pipe. At the first operation there must be sufficient air pressure to discharge the column of water which stands in the eduction pipe.

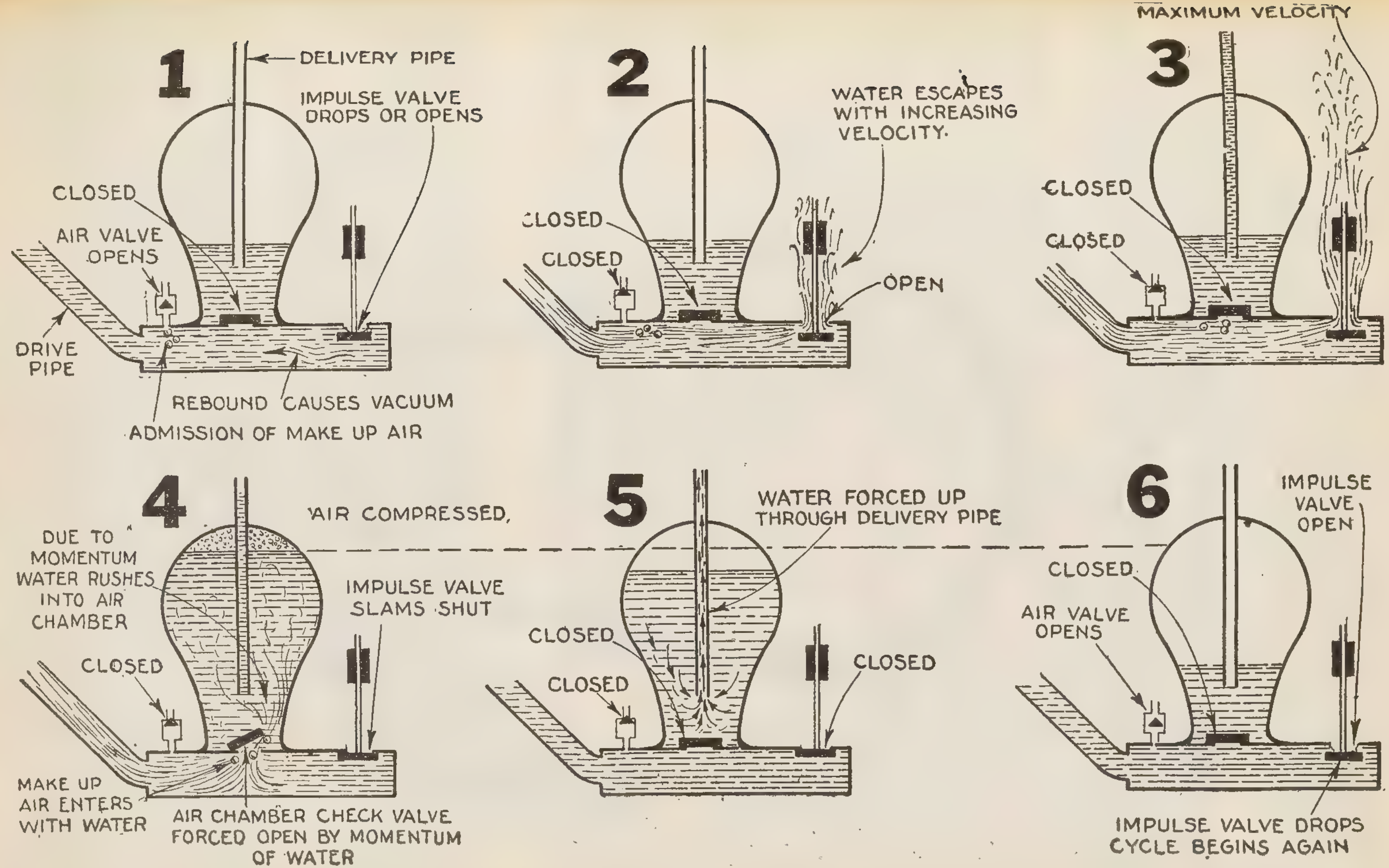
This goes out *en masse*, after which the pump assumes a normal condition, the air pressure being lowered and standing at such a point as corresponds with the normal conditions in the well. This is determined by the volume of water which the well will yield in a certain time and the elevation to which the water is discharged.

After the standing water column has been thrown off by the pressure the air rising through the water reduces its weight, with the result that the water is expelled as fast as the well supplies it, *the water outside the pipe acting as a head, flows into the discharge pipe by the force of gravity*.

The machinery necessary for a system of pumping comprises: 1, *an air compressor;* 2, a receiver to store and equalize the pressure; 3, the head piece and foot piece for the well; and 4, the necessary piping for the air supply and water discharge.

With an available supply of air under pressure *the pump proper consists of simply a water discharge and air pipe*, the latter arranged and properly controlled to inject air into the former at the point of proper submersion.

NOTE.—This extended description of the principles upon which an air lift operates—with its illustrations—is drawn almost word for word from the original patent claims of Dr. Pohle. The occupation of the space in the work is justified by the increasing importance of this system of water supply and its practical applications in the industrial world.



FIGS. 8,844 to 8,849.—Working cycle of hydraulic ram. **1**, slight vacuum due to rebound causes air check valve to open and admit small amount fo air; impulse valve drops, water begins to escape; **2**, velocity of escaping water increases; **3**, maximum velocity or full flow of escaping water; **4**, escaping water slams impulse valve shut, causing impulse which forces water (and air) into air chamber; **5**, inflow of water compresses air in air chamber which cushions impulse and forces water out through delivery pipe; **6**, impulse valve drops, cycle begins again. The positions of the various valves, at each instant depicted are plainly shown in the diagrams.

It is readily seen that the apparatus is so simple that as a pump it cannot get out of order; in cases where mud, sand or gritty material is encountered, it will handle such matter *with the water* and without injury to the system, as nothing comes in contact with the moving parts.

Hydraulic Ram.—By definition a hydraulic ram is *an impulse pump*. That is the energy due to the momentum of a long column of water made to force a portion of the water to an elevation higher than that of the source.

The water working the ram is supplied through a sloping pipe, and escapes through an opening; when its velocity exceeds a certain rate, it closes this opening by means of a balanced valve, which is made as light as consistent with strength; the sudden stoppage creates intense pressure in the ram and opens a delivery valve into an air vessel, and thence drives the water through the delivery pipe to its destination. As soon as equilibrium is restored, the delivery valve closes, the waste opens and the cycle recommences.

A double acting type of hydraulic ram is shown in figs. 8,852 and 8,853. It is more clearly described by considering it, first, as a single machine by disregarding its double supply feature.

First, in fig. 8,853, assume the opening at A, to be closed, the valve B, being open, the water from the source of supply from more or less elevation above the machine flows down the drive pipe A, and escapes through the opening at B, until the pressure due to the increasing velocity of the

NOTE.—In the operation of a hydraulic ram, it should be noted that a very slight descending column is capable of raising one ascending very high. In all cases the drive pipe or inlet pipe must be sufficiently long to prevent water being forced back into the reservoir. The air chamber serves to keep up a steady supply from the reservoir, preventing spasmodic action. To prevent admixture of air with the water in the air chamber, which is caused by pressure of water when raised to a great height, a small hole should be made on the upper side of the inlet pipe, immediately in front of the same. By the action of the ram at each stroke, a partial vacuum is formed below the air chamber, and the air rushing through the small hole in the inlet pipe, passes into the air chamber, making good that which the water absorbs.

water is sufficient to close the valve B. When the flow through this valve ceases, the inertia of the moving column of water produces a reaction, called the ramming stroke, which opens the valve at C, and compresses the air in the air chamber D, until the pressure of the air plus the pressure due to the head of the water in the main, is sufficient to overcome the the inertia of the moving column of water in the drive pipe. This motion may be likened to the oscillation of water in a U shaped tube.

The instant the column of water in the drive pipe comes to rest, and the air pressure being greater than the static head alone, the motion of the

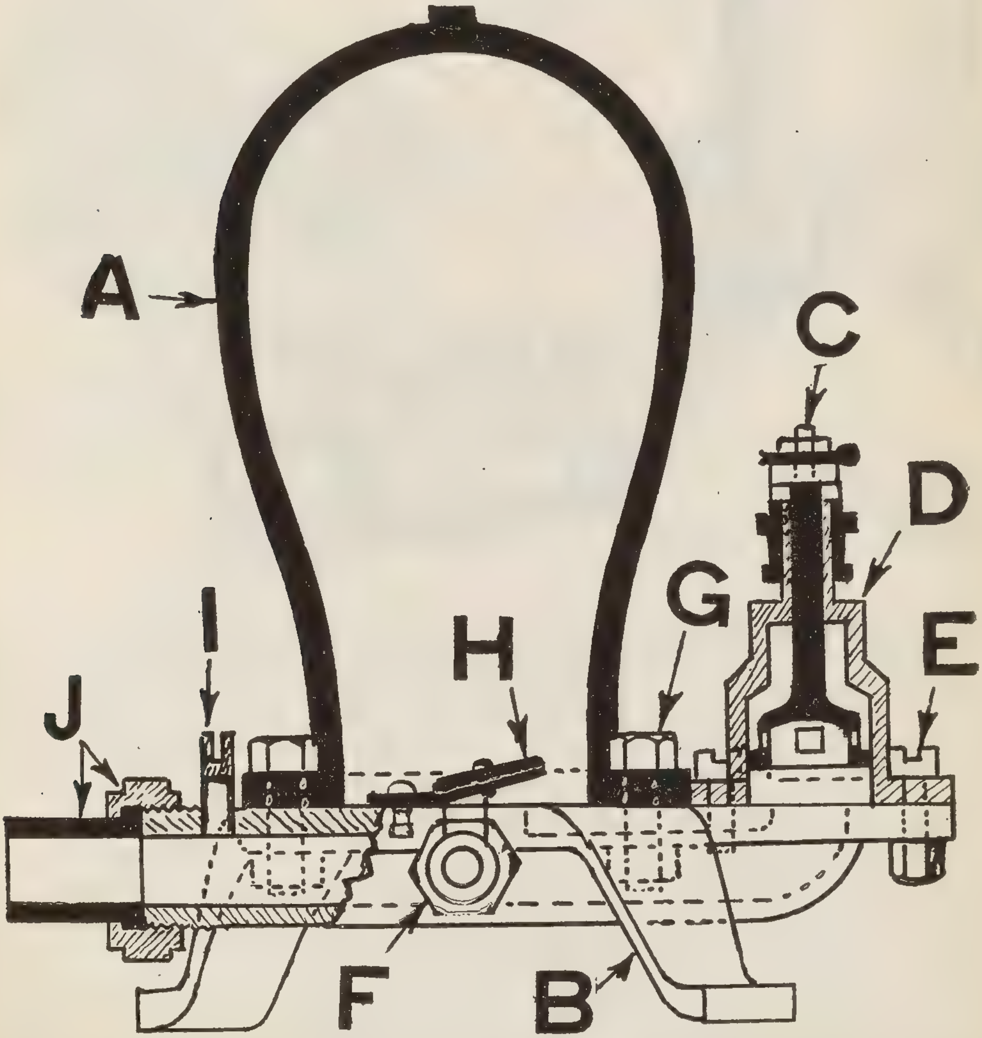


FIG. 8,850.—Sectional view of Rumsey ram. ***The parts are,*** A, air chamber; B, base; C, impetus valve; D. valve case; E, case screw; F, discharge nut and tube; G, air chamber bolt; H, check valve; I, snifting valve; J, drive nut and tube.

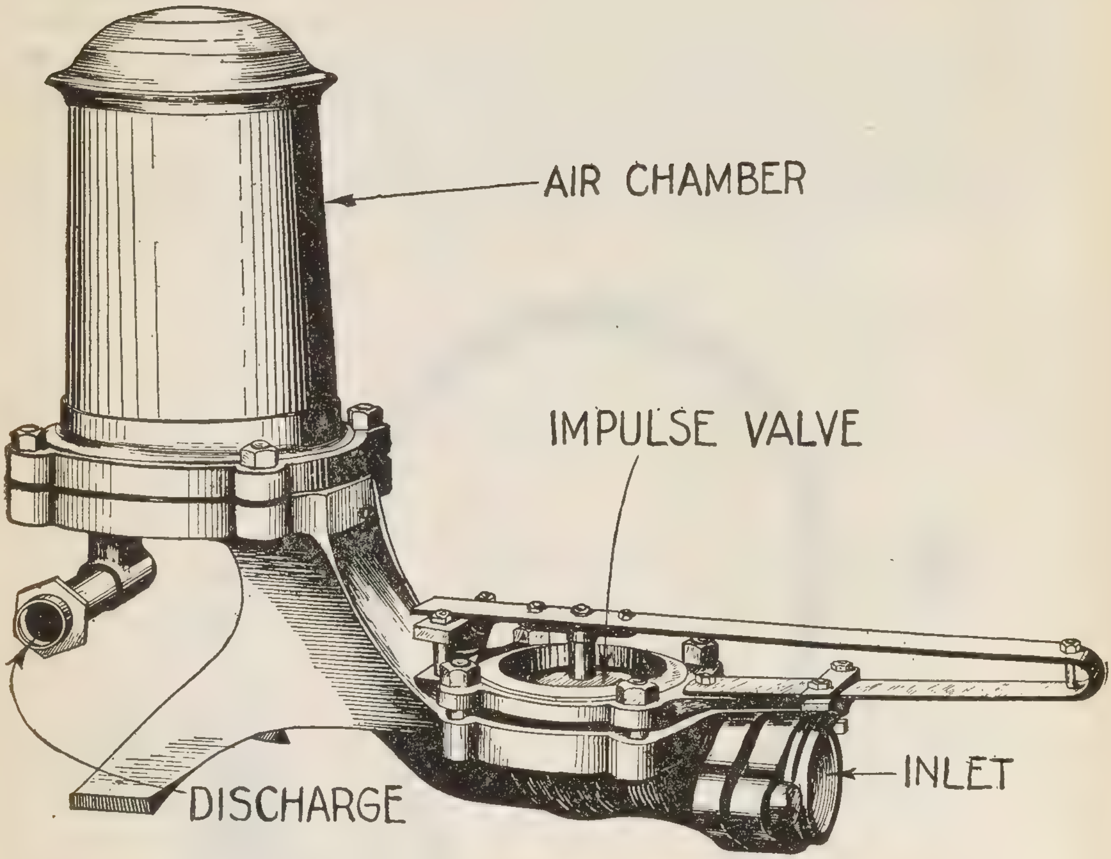
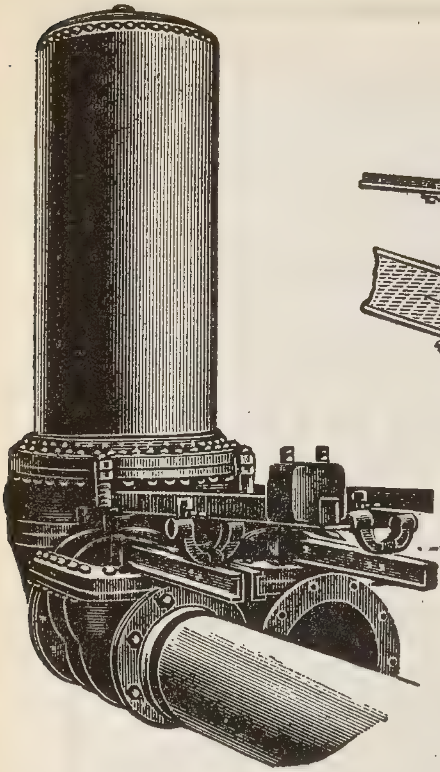


FIG. 8,851.—Rife ram. ***In construction,*** the escape valve is made of rubber supported by an iron washer underneath, bolting the rubber valve up against the lower face of the valve stem flange, the upper end of valve stem being bolted rigidly to a flexible spring steel lever, the valve rises and drops in the valve chamber true with the valve seat. The distance this valve drops in opening governs the amount of water used per minute up to the full capacity of the ram, for this purpose the lever rest is provided with a coiled steel spring underneath and two regulating bolts by which it may be raised or lowered, thus regulating the drop or opening of the valve. The delivery valve located inside the air chamber is also made of rubber, reinforced by a double flanged iron washer and is held in position by a rubber spring and iron clamp bolted rigidly to the base of the ram. ***To set the ram*** at full capacity the lever rest should be properly lowered and the bolt in the end of the lever sufficiently drawn that the opposite end lies gently upon the lever rest. In setting the ram to use less water per minute the manipulation of these bolts should be reversed. At no time should the water escape through the valve with force spurting from the opening; the lever rest should be lowered or the tension bolt in the end of lever slackened. The brass air feeder pin which regulates the air supply must always be sufficiently open that a little water escapes at each stroke of the ram. A metallic sound in the pipes or irregular flow at place of delivery indicates that the air pipe should be slightly opened while a quantity of air escaping at intervals, indicates it should be slightly closed.



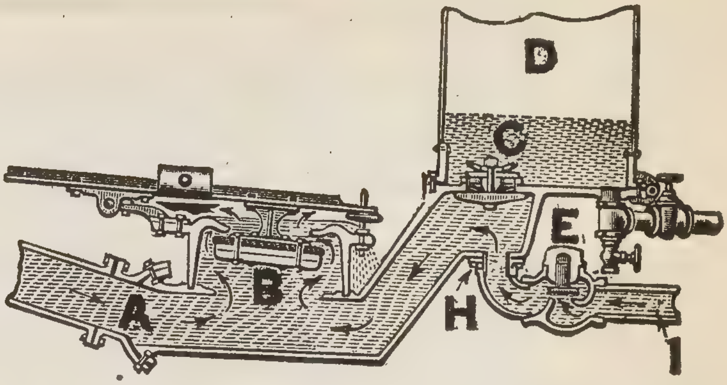


FIG. 8,852.—Rife double acting ram.

FIG. 8,853.—Sectional view of Rife double action ram.

NOTE.—***The efficiency of hydraulic rams*** has been much discussed; exhaustive practical tests have been made and the results have been reduced to formulæ. Whittaker's Mechanical Engineer's Pocket Book gives the following:

$$E = \frac{G \times H}{g \times h}$$

where E = the efficiency;
G = gallons of drive water used;
g = gallons of water raised;
H = height of fall, in feet;
h = height to which the water is raised, in feet.

NOTE.—The table on page 4,000 was prepared by *The American Engineer*. The following example illustrates its use: When the height of fall in feet is, say 12 feet, and the elevation of discharge above the delivery valve of ram, in feet, is 30 feet, *the efficiency* or per cent. is .3282. Thus for each 100 gals. 100 × .3282 = 32.82 gals. delivered.

EFFICIENCY OF HYDRAULIC RAMS

Height of fall in feet.	Elevation of discharge above delivery valve of ram in feet.														
	15	18	21	24	27	30	35	40	45	50	60	70	80	90	100
	Percentage.														
2	·0724	·0533	·0402	·0307	·0255	·0181	·0112	·0063	·0027	—	—	—	—	—	—
3	·1327	·1020	·0807	·0651	·0532	·0441	·0326	·0243	·0181	·0132	·0063	·0017	—	—	—
4	·1960	·1535	·1234	·1020	·0854	·0724	·0560	·0441	·0348	·0281	·0180	·0112	·0063	·0027	—
5	·2614	·2068	·1686	·1404	·1189	·1020	·0807	·0652	·0533	·0441	·0307	·0217	·0150	·0099	·0063
6	·3282	·2614	·2146	·1800	·1535	·1327	·1063	·0870	·0724	·0608	·0441	·0325	·0243	·0180	·0132
7	·3960	·3170	·2614	·2203	·1885	·1640	·1327	·1096	·0920	·0782	·0580	·0441	·0340	·0264	·0205
8	·4647	·3733	·3090	·2614	·2248	·1960	·1595	·1327	·1121	·0960	·0724	·0560	·0441	·0351	·0281
9	·5341	·4303	·3572	·3030	·2614	·2285	·1868	·1561	·1327	·1142	·0870	·0682	·0545	·0441	·0360
10	·6040	·4877	·4058	·3450	·2984	·2614	·2145	·1800	·1535	·1327	·1020	·0807	·0651	·0533	·0441
11	·6745	·5459	·4549	·3874	·3357	·2947	·2425	·2041	·1746	·1514	·1172	·0934	·0760	·0627	·0524
12	·7453	·6040	·5043	·4302	·3733	·3282	·2708	·2285	·1960	·1704	·1327	·1063	·0870	·0723	·0608
13	·8166	·6627	·5540	·4732	·4112	·3620	·2994	·2532	·2177	·1896	·1483	·1194	·0983	·0821	·0694
14	·8881	·7217	·6040	·5166	·4494	·3960	·3282	·2780	·2395	·2090	·1640	·1327	·1096	·0920	·0782
15	·9600	·7809	·6543	·5601	·4877	·4303	·3572	·3030	·2614	·2285	·1800	·1460	·1211	·1020	·0870
16	—	·8404	·7048	·6040	·5263	·4647	·3863	·3282	·2835	·2482	·1960	·1595	·1327	·1121	·0960
17	—	·9001	·7555	·6480	·5650	·4993	·4157	·3535	·3058	·2680	·2123	·1731	·1444	·1223	·1050
18	—	·9600	·8064	·6921	·6040	·5341	·4451	·3790	·3282	·2880	·2286	·1868	·1561	·1327	·1142
19	—	—	·8574	·7364	·6430	·5690	·4746	·4046	·3507	·3081	·2449	·2006	·1680	·1430	·1262
20	—	—	·9086	·7800	·6823	·6040	·5042	·4303	·3733	·3282	·2614	·2145	·1800	·1535	·1327
21	—	—	·9600	·8254	·7217	·6392	·5340	·4561	·3960	·3486	·2780	·2286	·1920	·1640	·1420
22	—	—	—	·8701	·7612	·6745	·5640	·4820	·4188	·3688	·2947	·2425	·2041	·1746	·1514
23	—	—	—	·9150	·8007	·7098	·5940	·5080	·4417	·3892	·3114	·2567	·2163	·1853	·1609
24	—	—	—	·9600	·8404	·7433	·6241	·5341	·4657	·4097	·3282	·2708	·2185	·1960	·1704

moving column is reversed, and the valve C, closes. The water in the drive pipe then moves backward, and with the closing of valve C, a partial vacuum is formed at the base of the drive pipe. This negative pressure causes the valve B, to open again, and completes the cycle of operations. At the moment negative pressure appears the little snifting valve E, admits a small quantity of air, and at the following stroke this air rises into the air chamber D, which would otherwise gradually fill with water, or the air is gradually absorbed by the water.

In this machine the valve B, is made as light as is consistent with the necessary strength, and the negative pressure at the completion of the stroke opens the valve.

In the largest size of these machines this valve is 18 inches in diameter, with a head of 8 ft., which is a common head for use with hydraulic rams; the static pressure on the under side of this valve is 883 lbs.; it is seen that so great a shock in a valve of this weight would rapidly destroy both valve and seat.

The waste in a mechanism of the Rife ram consists of a large port with ample opening and a large rubber valve or overflow with a balance counterweight and spring seat, which removes almost entirely the jar of closing.

The valve C, in the air chamber consists of a rubber disc with gridiron ports and convex seats fastened at the center and lips around its circumference. The object of this arrangement is to transfer the shock from the power of the driving water to the air cushion with the smallest possible friction and vibration.

After the valve C, closes, the pressure .n the air chamber forces the water in the air chamber out into the delivery pipes. The Rife ram is claimed to elevate water 30 feet for each foot of fall in the driving head; the machine is built in sizes to elevate as much as 150,000 gallons per day, the efficiency being about 82 per cent.

When a water supply pipe is attached to H, the ram is called *double acting*; spring water, or that which is purer than the water used to drive the ram, may then be supplied through the supplemental drive pipe I, and by a proper adjustment of the relative flow of the impure driving water, and that of the pure supply, the ram may be made to deliver only the pure water into the mains. This method is employed where the supply of pure water is limited.

The most important detail in which the Rife ram differs from other rams is *the waste valve*. It will be seen in the engraving that the counterweight on the projecting arm of this valve permits the adjustment of

this valve to suit varying heads and lengths of drive pipe. By adjusting the counterweight so that the valve is nearly balanced, the valve comes to its seat very quickly after the flow past it begins. The result is that the ram makes a great number of short, quick strokes, which are much easier on the valves and seats than slower and heavier strokes. The stroke must be sufficiently powerful to act efficiently in overcoming the head in the delivery pipe. The adjustable weight permits this to be effected with great nicety.

How to Install a Ram.—The water is conducted to the

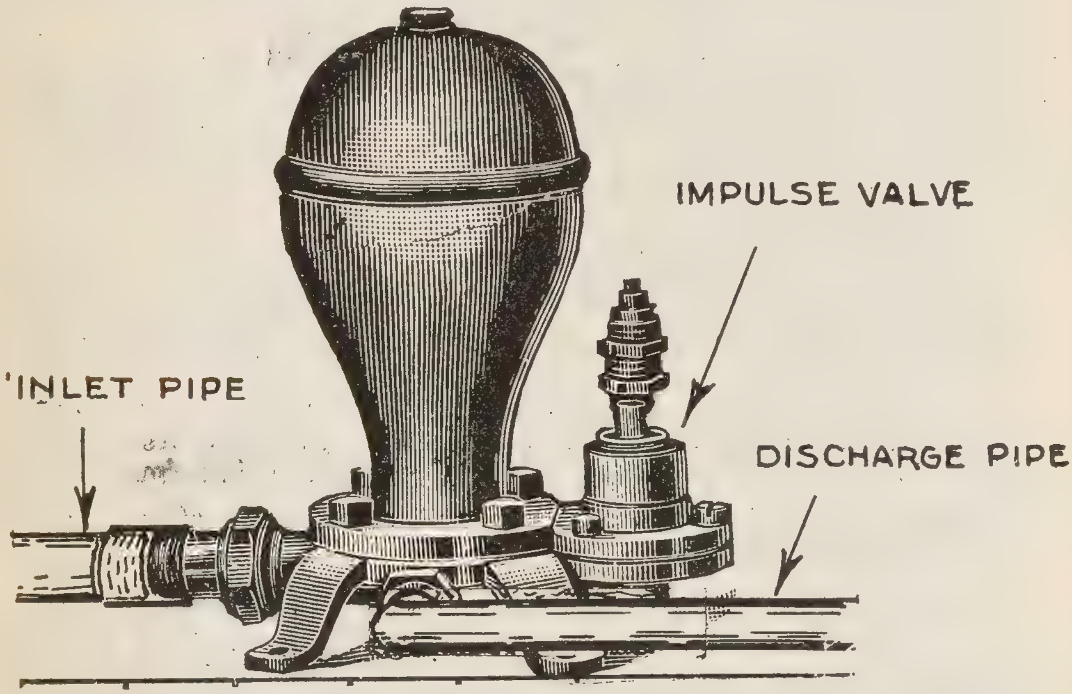


FIG. 8,854.—Columbiana hydraulic ram made in sizes ranging from ½ to 2 gal. per minute. to 6 to 14 gals. per minute.

ram by the drive pipe. This pipe should incline gradually to the ram and be free from sharp turns or elbows. The length of the drive pipe should be at least equal to two-thirds the delivery head, or five times the drive head. The inclination of the drive pipe should never be over 30 degrees at any place, and when the length or proper angle can not be had it is well to coil the drive pipe to a large radius so as to accomplish this. The drive pipe should be air tight.

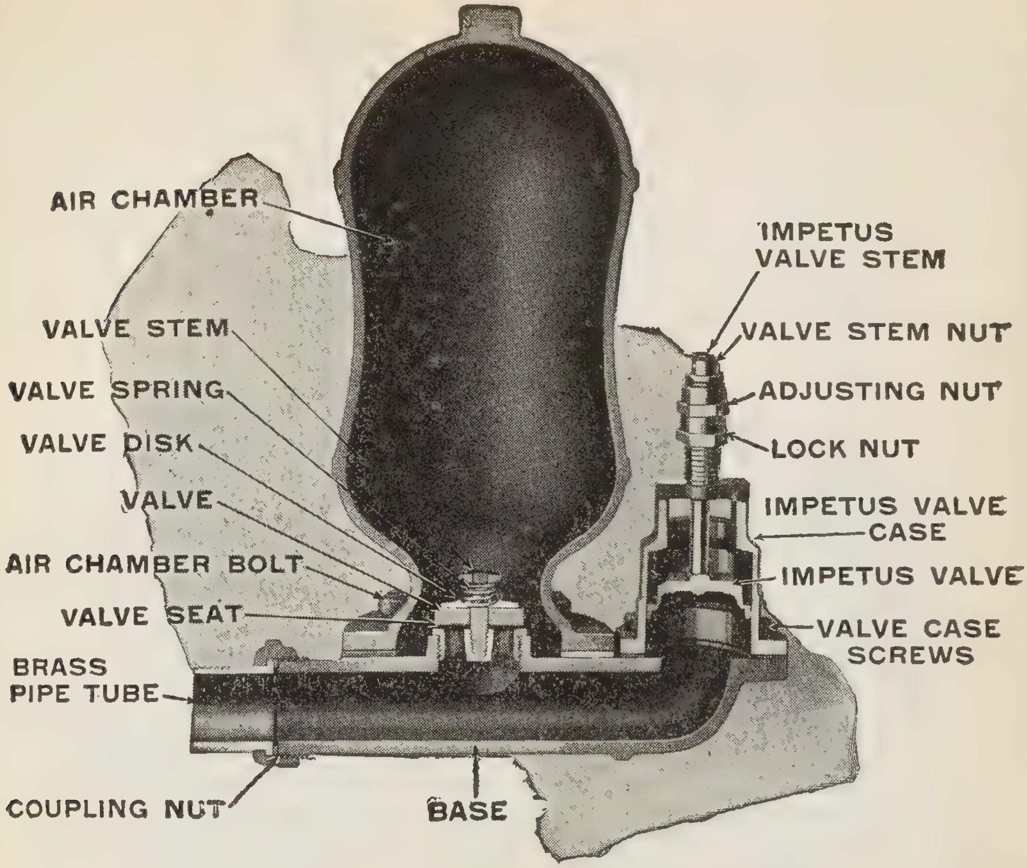


FIG. 8,855.—Sectional view of Deming ram showing construction. ***Special installation hints:*** The length of the drive or supply pipe should not be less than five times the fall. The fall should not be greater than one-half the elevation nor less than one-tenth, if good results are to be obtained. The discharge pipe may be any length, provided the pipe is of sufficient size. Be sure that all pipe connections are air tight. Connect all pipes before starting the ram, and leave them uncovered until it is found that there are no leaks. The upper end of the drive pipe should always be a foot or more below the surface of the water. It should be located six or more ins. above the bottom of reservoir and a strainer placed on end of pipe. Pipes should be laid straight to reduce friction. Where turns are necessary long bends are better than abrupt angles. Locate the ram in a masonry lined pit, and bolt it on a level foundation. Provide drainage for waste water from the bottom of pit. Place all pipes below the frost line. When the ram is placed in a pit have pit large enough in diameter so it is easily reached for adjustment or repairs.

NOTE.—***Batteries of rams.*** In many cases larger capacities are desired than it is practical for one ram to handle to good advantage. For such conditions several rams should be installed, connecting into a single discharge pipe. This also makes it possible to secure varying quantities of water as desired, since any one or more of the rams may be shut down independent of the others.

Handy Table Showing How to Find Number of Gallons a Deming Ram Will Deliver Per Day of 24 Hours

Fall in Feet	ELEVATION IN FEET																		
	4	6	8	10	12	14	16	18	20	25	30	35	40	50	60	70	80	90	100
	The Figures Below Represent (Theoretical) Number of Gallons Discharged in 24 hours for Each Gallon of Water Per Minute Supplied to the Ram																		
2	360	240	180	144	120	102	90	80	72	...	...	...	...	...	...	...	...	...	...
3	...	360	270	216	180	153	135	120	108	86	72	...	...	...	...	...	...	...	...
4	...	...	360	288	240	204	180	160	144	115	96	82	72	...	...	...	...	...	...
5	...	...	...	360	300	255	225	200	180	144	120	102	90	72	...	...	...	...	...
6	...	...	...	...	360	309	270	240	216	173	144	123	108	86	72	...	...	...	...
7	...	...	...	...	...	360	315	280	252	201	168	143	126	100	84	72	...	...	...
8	...	...	...	...	...	...	360	320	288	230	192	164	144	115	96	82	72	...	...
9	...	...	...	...	...	...	...	360	324	259	216	184	162	129	108	92	81	72	...
10	...	...	...	...	...	...	...	...	360	288	240	205	180	144	120	102	90	80	72

The figures in the above table are based on a Ram efficiency of 50 per cent.

NOTE.—It is absolutely necessary before a ram can be installed to have at least two ft. of fall, vertical distance from the surface of the water in the supply reservoir to the level of the ram. There should be one ft. of fall for each five to ten ft. of elevation, *i.e.*, the vertical distance from the ram to point of discharge. With sufficient fall in relation to elevation, the other details can usually be worked out without difficulty. It is seldom that two installations are exactly alike.

NOTE.—***Information required.*** Fall in feet vertically from surface of water in the supply reservoir to level of the hydraulic ram. Number of gals. of water per minute supplied to the ram. Elevation or height in ft. (vertically above level of ram) at which water is to be discharged. Quantity of water per day of 24 hrs. (in gals.) required to be discharged into storage tank. Length of drive pipe in ft. It should not be less than five times the fall to give best results. It may, however, be longer. Length in ft. of discharge pipe.

NOTE.—***How to use the table.*** First, find out what fall and elevation is required, also number of gals. per minute supplied to the ram. Then multiply number in column opposite fall, and under elevation by the number of gals. per minute which will be supplied to the ram. The result will be the number of gals. discharged per day of 24 hrs.

Example.—With a supply of 16 gals. per minute, a fall of 5 ft., an elevation of 30 ft., No. 6 Deming ram (which uses 12 to 25 gals. per minute) will deliver approximately $16 \times 120 = 1920$ gals. per day of 24 hrs.

NOTE.—***The relation of fall to elevation*** should always be kept within the limits shown in above table, *i.e.*: the elevation should not exceed ten times the fall; and the fall should never be greater than one-half the elevation nor less than one-tenth the elevation, if good results are to be obtained. A ram of ample size for the requirements should always be selected, when the water supply will permit.

The length of delivery pipe should not be over twenty times the lift or height to which water is to be forced above the ram. The size of the drive pipe should always be the same as that for which the ram is fitted. The delivery pipe should never be less than the size for which the ram is fitted, but in case the ram is at considerable distance from the reservoir the loss due to friction in the pipe may be cut down by

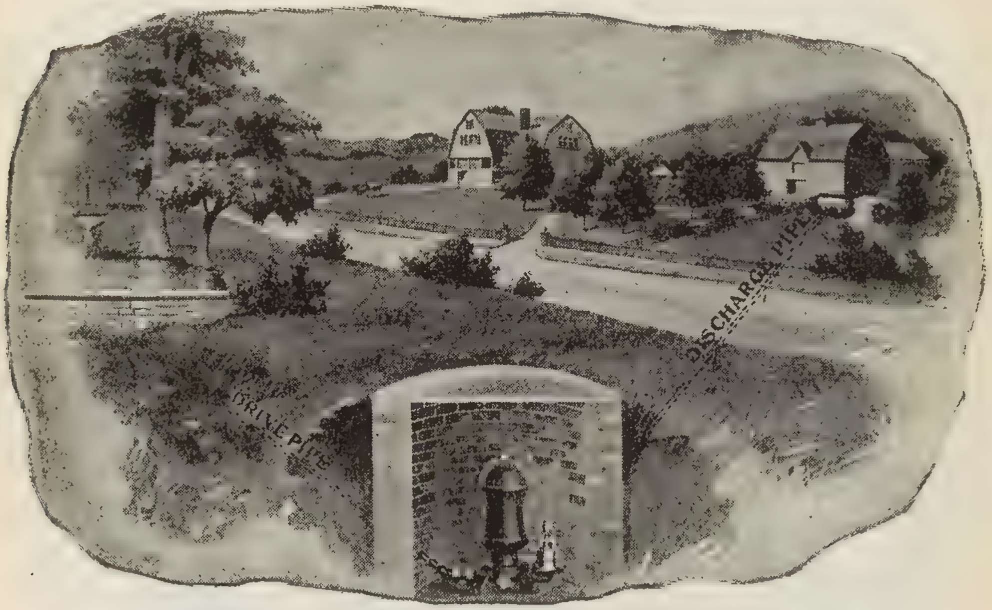


FIG. 8,856.—Installation of ram discharging in house tower. The fall is the vertical distance from the level of the spring to the ram's base. The elevation is the vertical distance from the ram to the tank.

using a larger pipe, and therefore the amount of water delivered will be increased. Gate valves should be placed on the drive and delivery pipes as close to the ram as possible.

A strainer should be placed over the end of the drive pipe at the source to prevent leaves and other foreign substances passing down to the ram. Unless the pipes be free from obstruction, the ram will not work properly.

Where it is impossible to obtain sufficient fall within the required length of pipe, the water may be conveyed any

distance and an open stand pipe or barrel placed in the pipe line at the required distance from the ram.

The ram should always be securely fastened on timbers or on masonry foundation and not left dependent merely upon pipe connections. Turns or bends in either drive or discharge pipe should be as few as possible, and when it is necessary to make a turn, bend the pipe in preference to using elbows.

Where it is necessary to use elbows in the discharge pipe, have them

FIG. 8,857.—Installation of ram. ***The drive pipe*** should be five or six times as long as the fall is high. If the ram must be at a distance from the supply to get sufficient fall, pipe the water to a barrel set at the right point. Lay the drive straight on a gradual incline, bending it just enough to connect to the ram. If the drive pipe should be found to be too long for the amount of fall secured then the water should be piped from the source of supply to a point within the required distance of the ram. At this point, an open barrel should be placed and the drive pipe connected to it, or should the fall be so great as to interfere with the operation of the ram, adoption of the same plan is advised. The pipe leading from the source of supply to the barrel should be at least a size larger than the drive pipe between the barrel and the ram.

as large as possible to overcome friction. A drain should be provided to carry off the waste water, and the ram should be suitably housed to prevent freezing in cold weather. Care should be taken to see that all

scale and sediment is removed from the drive pipe before connecting to ram, as this sediment works loose and collects in the impetus valve, which decreases the efficiency and at times closes it entirely.

Ram Calculations.—After it has been determined how high the water delivered by the ram is to be raised, the following table by Humphreys will give the necessary number of feet fall and the length of drive pipe required for the successful operation of the ram:

To Deliver Water to the following Delivery Heads	Place Ram Under	Conducted Through
20 feet above ram	5 feet Drive Head	30 feet of drive pipe
30 " " "	6 " " "	30 " " " "
40 " " "	8 " " "	40 " " " "
50 " " "	10 " " "	50 " " " "
60 " " "	12 " " "	60 " " " "
80 " " "	16 " " "	80 " " " "
100 " " "	20 " " "	100 " " " "
120 " " "	24 " " "	125 " " " "

Example.—If the total vertical distance from level of the ram to point of delivery be 80 feet, from the above it will be seen that it is necessary to place ram 16 feet lower than the water which supplies the ram, and to use 80 feet of drive pipe. Any size of hydraulic ram can be used under the above conditions.

In order to ascertain the approximate quantity of water which a certain ram will deliver, it is necessary to determine the number of gallons of water available for its supply, the fall from the supply to the ram and the vertical height to which the water will be forced by the ram. When this is known, the approximate delivery may be secured by the use of the Table of Capacities on page **2462.** *Multiply the factor opposite drive head and under delivery head by the number of gallons used per minute by the ram.* The result will be the number of gallons delivered by the ram in twenty-four hours.

Example.—With a supply of 5 gals. per minute under a fall of 6 ft. and a delivery head of 20 ft., according to Humphreys, a Humphreys No. 4

TABLE OF CAPACITIES

Drive Head in feet	Delivery Head in Feet 10	15	20	30	40	50	60	70	80	90	100	120	140	160	180	200
4	432	288	216	144	108	76	64	55	48	43	38	32	....	....	....	....
5	540	360	270	180	135	108	80	69	60	54	48	40	34	....	....	....
6	....	432	324	216	162	130	108	82	72	64	58	48	41	36	32	....
7	....	505	378	252	189	151	126	108	84	75	68	56	48	42	37	....
8	....	....	432	288	216	173	144	123	108	86	78	64	55	48	42	38
9	....	....	486	324	243	194	162	139	121	108	86	72	62	54	48	43
10	....	....	540	360	270	216	180	154	135	120	108	80	69	60	53	48
12	....	....	....	432	324	259	216	184	162	144	130	108	83	72	64	57
14	....	....	....	505	378	303	252	216	189	168	151	126	108	84	75	66
16	....	....	....	....	432	346	288	247	216	192	173	144	123	108	86	77
18	....	....	....	....	486	389	324	278	243	216	194	162	138	121	108	86
20	....	....	....	....	540	432	360	308	270	240	216	180	154	135	120	108
22	....	....	....	....	....	475	396	339	296	264	237	198	169	148	132	118
24	....	....	....	....	....	519	432	370	324	288	259	216	184	161	144	130
26	....	....	....	....	....	....	468	401	350	312	280	234	200	175	156	140
28	....	....	....	....	....	....	505	432	378	336	303	253	216	188	168	151
30	....	....	....	....	....	....	540	463	405	360	324	270	231	202	180	161

ram will deliver approximately 5 times 324 or 1,620 gals. of water in 24 hours.

For a small supply, the amount of water available per minute can easily be determined by the length of time required to fill an ordinary gallon pail.

How to Measure Flow of Water.—The flow from a spring or a brook usually determines the proper size ram to install, small springs or streams should be conveyed by means of a pipe or trough into a vessel for one minute or less, and the contents measured, thus accurately obtaining the flow of gallons per minute. If fall be insufficient to convey the water into a bucket or tub, sink the vessel in the ground (or water) until it passes under the end of pipe or trough.

The following rule (according to Rife) gives the number of gallons of water that may be delivered per hour to a given point.

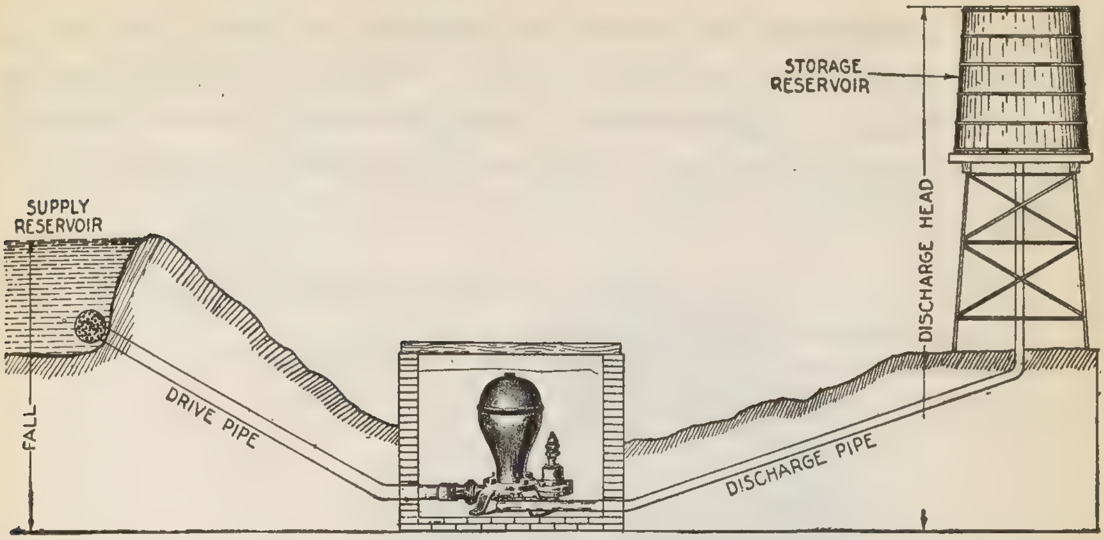


FIG. 8,858.—Columbiana ram installation to accompany table of proportionate head of fall giving highest efficiency in operation of hydraulic rams.

Relative Head and Fall giving Maximum Efficiency
(According to Columbiana Pump Co.)

To deliver Water to Height of	Place Ram Under	Proper Length of Drive Pipe
20 feet above ram	3 feet head or fall	30 feet of drive pipe
30 " " "	4 " " " "	30 " " " "
40 " " "	5 " " " "	40 " " " "
50 " " "	7 " " " "	50 " " " "
60 " " "	8 " " " "	60 " " " "
80 " " "	10 " " " "	80 " " " "
100 " " "	14 " " " "	100 " " " "
120 " " "	17 " " " "	125 " " " "

*Any size ram may be operated under these conditions and will afford the following approximate delivery:

No. 2	require	2 to 3	gals. per min	and del.	10 to 15 gals. per hour
" 3	"	2 " 4	" " "	" "	10 " 20 " " "
" 4	"	3 " 7	" " "	" "	15 " 35 " " "
" 5	"	6 " 12	" " "	" "	30 " 60 " " "

*NOTE.—The rams referred to are Columbiana rams. The length of the drive or supply pipe should not be less than ¾ of the height to which the water is to be raised, or 5 times the height of supply; it may, however, be longer. The hydraulic ram is most efficient when the volume of the air chamber is equal to the volume of the discharge pipe. The larger size rams, when an abundance of water is supplied, are adapted for elevating to the greatest heights and longest distances. The discharge pipe should not be longer than 10 times the height of discharge.

Rule.—*Multiply the number of gallons the spring or stream flows per minute by the feet in fall. Multiply this product by* 40, *then divide by the number of feet the water is to be elevated above the ram.* The result will be the number of gallons delivered per hour.

Example.—If the flow of water be 15 gals. per minute under 8 ft. head, how many gallons delivered per hour.

Flow of water per minute.................15 gallons
Fall of same.............................. 8 feet

$$\begin{array}{r} 120 \\ 40 \\ \hline 50)4800 \\ \hline \end{array}$$

96 gallons delivered per hour

The following rule by Rumsey gives the number of gallons delivered per 24 hours:

Rule.—*Multiply the number of gallons furnished by the spring per minute, by* 936; *multiply this product by the height of the spring (in feet) above ram; then divide by the height (in ft.) between ram and point of delivery.* The result will be the number of gallons delivered per day of 24 hrs.

Points Relating to Rams.—1. Where the water supply is limited, a ram must be used which the spring will furnish with at least the minimum quantity of water stated by the manufacturer of the ram selected.

2. Where the water supply is abundant, the selection of the proper size of ram is governed by the quantity of water desired per day. If more water be desired than a single ram can furnish, batteries of two or more rams may be employed, each having a separate drive pipe but discharging into a common delivery pipe.

3. A ram will operate with an 18 in. fall, but will pump further when the fall is greater.

4. A fall of 10 ft. is sufficient to raise water 150 ft. or more.

5. When the water has to be carried to a distance, the ram also has to overcome friction in the pipe which should be considered as part of the elevation.

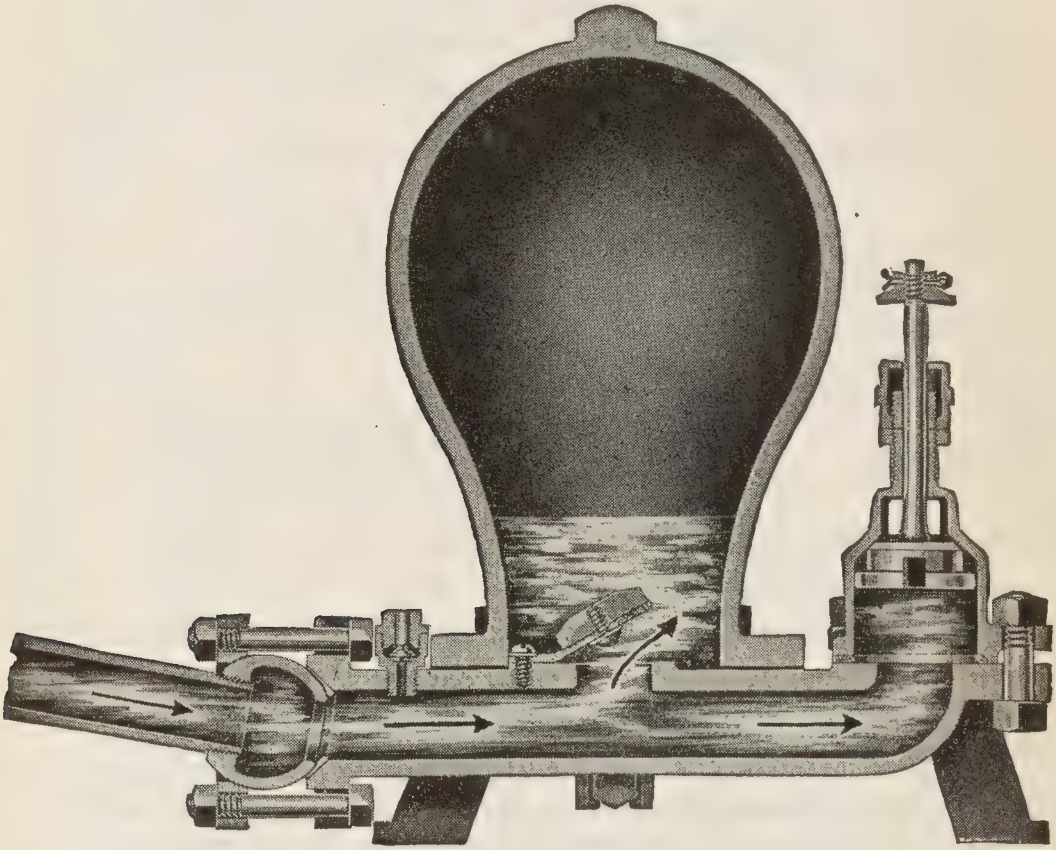


FIG. 8,859.—Humphreys ram. ***To start the ram,*** open the valve in the drive pipe and close the valve in delivery pipe. Work the impetus valve up and down by hand a few times and as pressure in the air chamber increases the impetus valve will work automatically and when this occurs gradually open the valve in delivery pipe and allow water to be forced up through this pipe to reservoir. Unless the pressure in the air chamber be greater than the pressure due to the height of source above ram the impetus valve will be forced shut and stay so; hence by closing the valve in delivery pipe the pressure in the air chamber increases rapidly and the ram begins its operations at once.

6. The proportion between the amount of water taken from the spring and the amount delivered to the tank depends on the relative height of fall and elevation.

7. In conveying water to a distance of 800 to 900 ft. from the ram, about one-tenth of the amount driving the ram can be raised to an

elevation ten times as high as the fall, or about one-seventh can be raised five times as high as the fall.

8. With a fall of 5 ft. of every seven gals. drawn from the spring, one may be raised 25 ft. or a little more than half a gallon 50 ft.

9. Make all joints tight.

10. Place the upper end at least a foot under water and protect it with a strainer coarse enough to permit a free flow.

11. A full way gate to shut off the water is convenient.

12. Avoid sharp turns or elbows as far as possible and make all joints tight.

13. Put a full way gate valve near the ram.

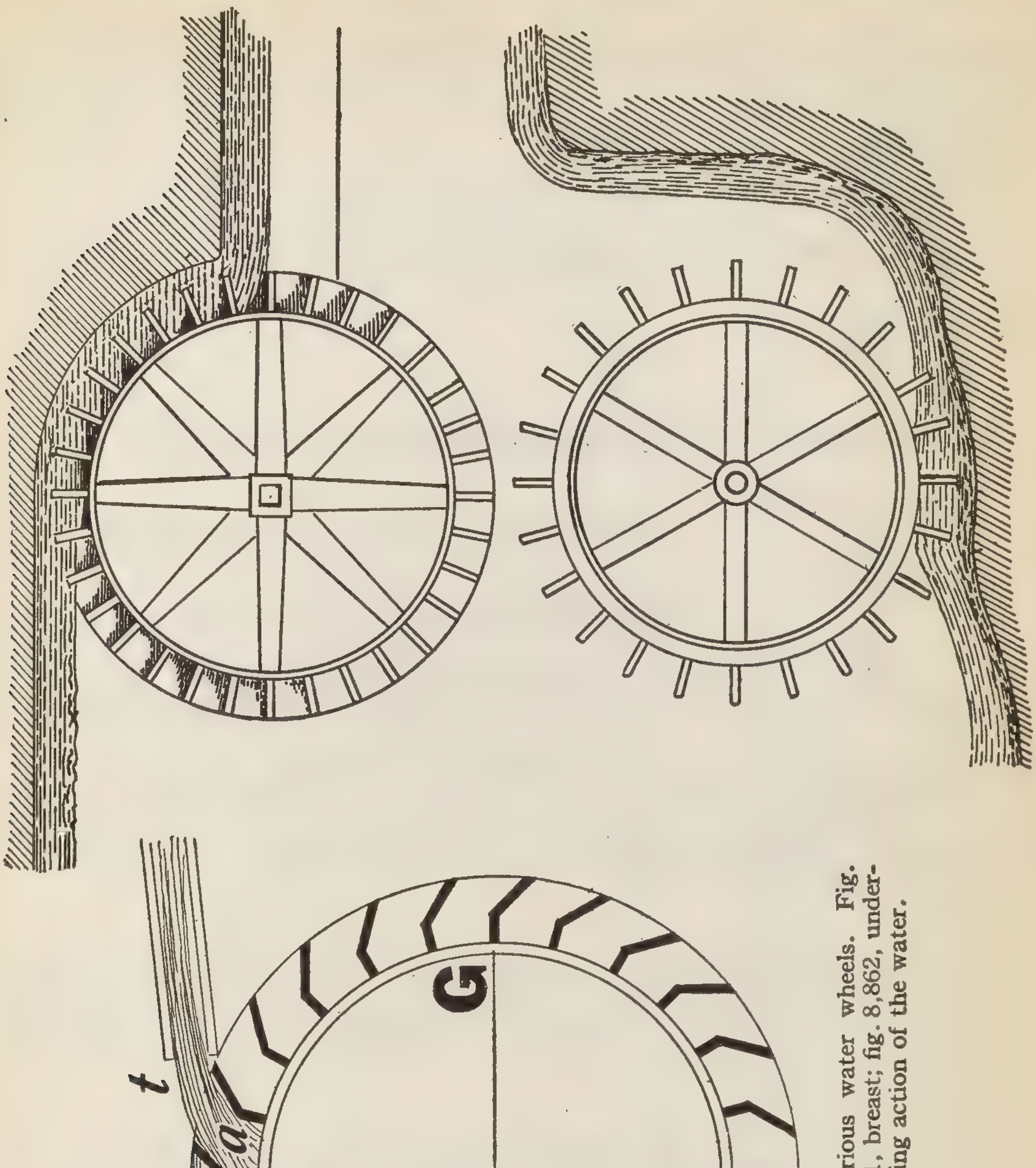
14. In setting, the ram should be bolted to a level foundation of timber or concrete. It is best located in a covered pit with a drain for the waste water.

Troubles.—1. Should the ram stop with the impetus valve up, there is a leak somewhere about the valve seat or flange which must be located and stopped. No weight is needed on the impetus valve to make it drop. It is heavy enough to drop of itself, if there be no pressure under it from leakage.

2. Should the ram stop with the impetus valve down, it is evidence of an insufficient supply of water. The strainer may be stopped up or the gate way not have opened wide enough. If the water level in the spring be drawn down, the trouble lies with the quantity of water furnished. The ram can then be adjusted to a shorter stroke to use less water and if necessary one or more of the valve ports can be closed up by forcing dry wood into the opening or soldering in a piece of brass.

3. If the ram operate and deliver no water, the air may be exhausted from the air chamber. To refill it, shut off the pipes and take off the cap on the opposite side from the discharge pipe. If the impetus valve be making an upward stroke and then fluttering at the top, there is air in the drive pipe. Either the pipe is leaking or else its end is not completely submerged in the spring. An obstruction lodged under the check valve so as to prevent its closing may also cause this trouble.

Water Wheels.—These *water wheels* are large vertical wheels



FIGS. 8,860 to 8,862.—Various water wheels. Fig. 8,860, overshot; fig. 8,861, breast; fig. 8,862, undershot. Diagrams illustrating action of the water.

driven by water falling from a higher to a lower level; they are motors on which the water acts, partly by weight, partly by impulse.

There are several types of water wheels, classed:

1. According to the action of the water, as

    1. Impact
    2. Weight

2. According to the point of delivery of the water, as

    1. Overshot
    2. Breast
    3. Undershot

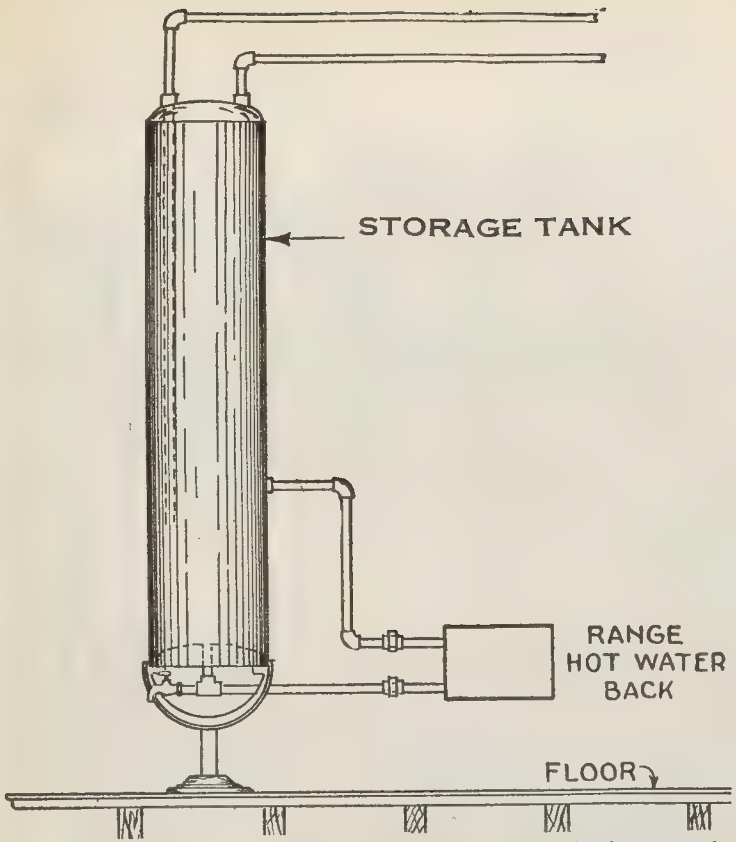
Fig. 8,860 represents an *over-shot water wheel* (H F L G, with axis at O) in which the water flows upon the top of the wheel at *t*, in the same direction in which it revolves, therefore the impact of the water is utilized upon the upper buckets *a*,*b*,*c*, after which the weight of the water acts in the buckets *d*,*e*,*f*,*g*,*h*,*i*, and *j*.

At *c*, the buckets begin to overflow and empty themselves as shown. It will be seen that the water acts upon almost one-half the circumference of this wheel, thus realizing the greatest mechanical effect with the smallest quantity of water.

In the *breast wheel*, as shown in fig. 8,861, the water is admitted on a level or slightly above the center of the shaft, so that the water acts by impact and weight.

Fig. 8,862 shows an *undershot water wheel*. In this style of wheel, the work is done by impact alone, as the running water acts only on a few immersed buckets on the under side of the wheel.

Hot Water Supply.—This subject has been treated at such



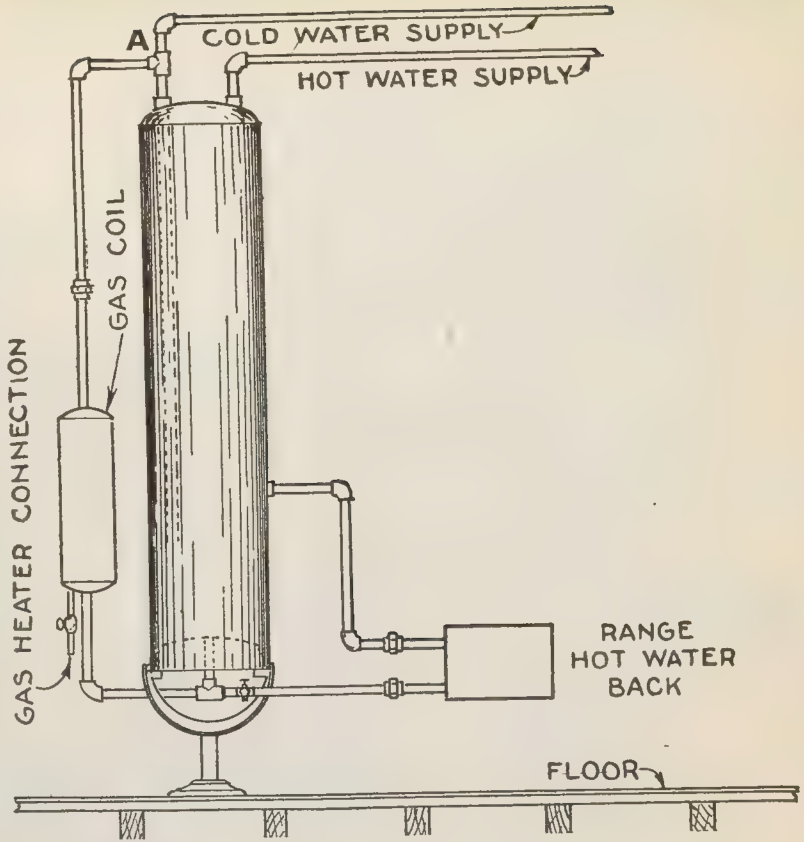


FIG. 8,863.—Hot water tank piping. 1, with single water back.

FIG. 8,864.—Hot water tank piping. 2, with water back and gas ***peak booster*** for overloaded system. The gas coil is used only at such times when the demand for hot water is too great to be met by the water back alone. ***In operation,*** the heat from the gas heater is delivered to the lower part of the tank, thus preventing overheating at the top during no demand periods. There should be a flow T at **A**, directing hot water at A, downward, the incoming cold water accelerating circulation of hot water from coil, mixing in internal tube with resulting warm water discharge at lower end.

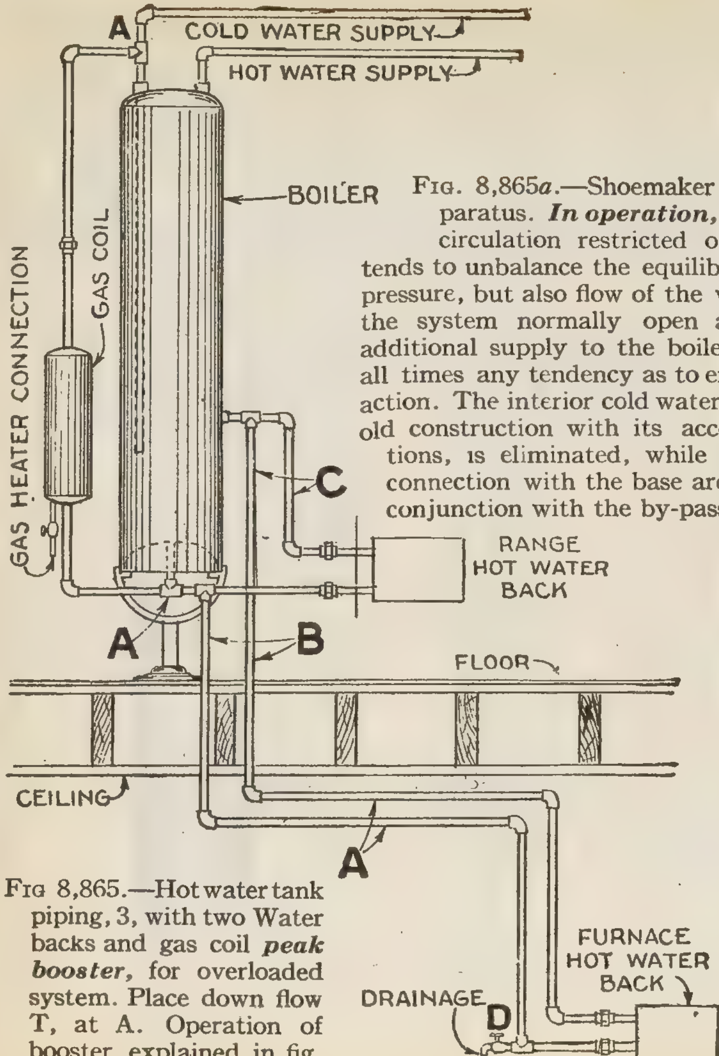


FIG 8,865.—Hot water tank piping, 3, with two Water backs and gas coil ***peak booster,*** for overloaded system. Place down flow T, at A. Operation of booster explained in fig. 8,864.

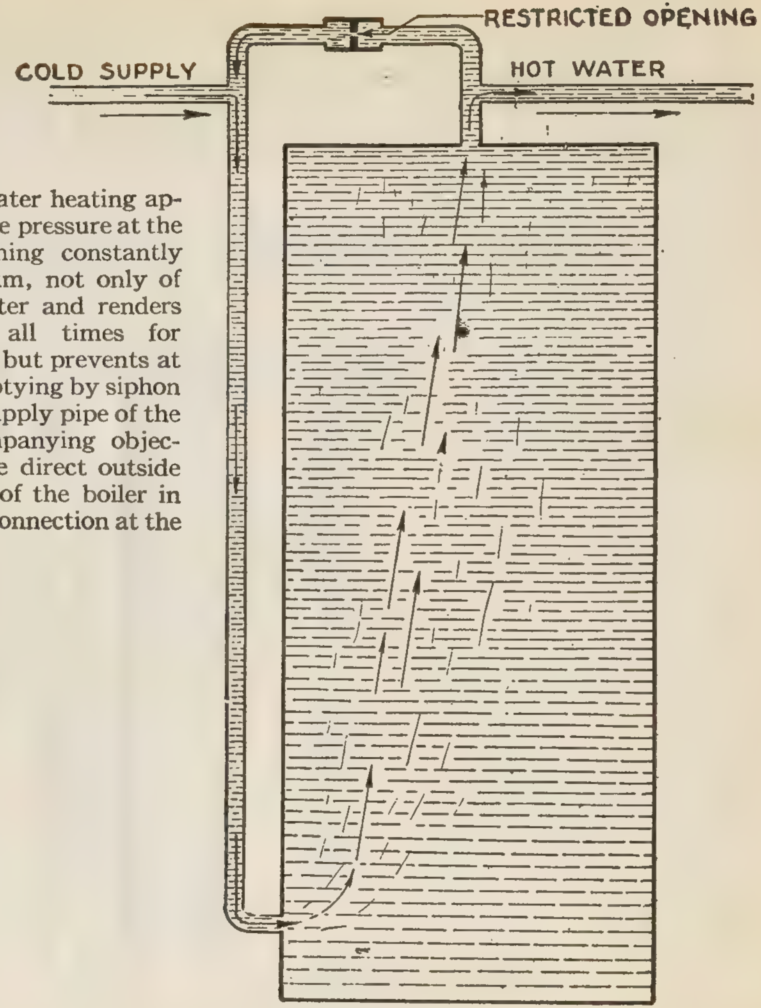


FIG. 8,865*a*.—Shoemaker water heating apparatus. ***In operation,*** the pressure at the circulation restricted opening constantly tends to unbalance the equilibrium, not only of pressure, but also flow of the water and renders the system normally open at all times for additional supply to the boiler, but prevents at all times any tendency as to emptying by siphon action. The interior cold water supply pipe of the old construction with its accompanying objections, is eliminated, while the direct outside connection with the base area of the boiler in conjunction with the by-pass connection at the top with the hot water delivery pipe through the restricted opening, ensures continuous service operation with the advantage of simplicity and economy as to original installation and cost.

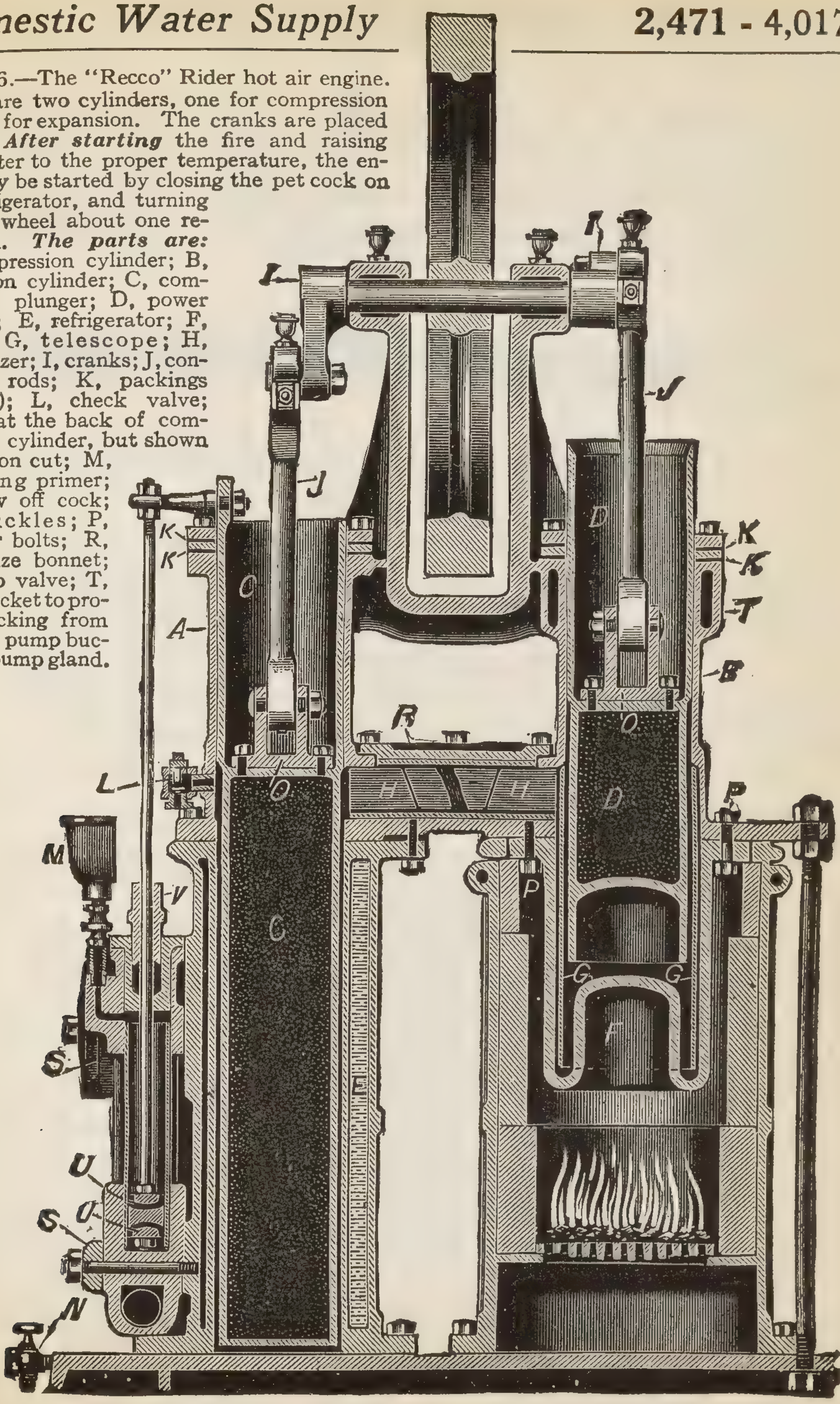


FIG. 8,866.—The "Recco" Rider hot air engine. There are two cylinders, one for compression and one for expansion. The cranks are placed at 95°. ***After starting*** the fire and raising the heater to the proper temperature, the engine may be started by closing the pet cock on the refrigerator, and turning the fly wheel about one revolution. ***The parts are:*** A, compression cylinder; B, expansion cylinder; C, compression plunger; D, power plunger; E, refrigerator; F, heater; G, telescope; H, economizer; I, cranks; J, connecting rods; K, packings (leather); L, check valve; placed at the back of compression cylinder, but shown at side on cut; M, pumping primer; N, blow off cock; O, knuckles; P, heater bolts; R, economize bonnet; S, pump valve; T, water jacket to protect packing from heat; U, pump buckets V, pump gland.

great length in the first chapter of Elements of Sanitation (Guide No. 2) that little need be added here. The accompanying series of illustrations show various ways of piping up hot water storage tanks commonly but erroneously called "boilers."*

*NOTE.—***It is past understanding*** why anyone with ordinary intelligence will refer to these tanks as boilers, and would require a considerable stretch of the imagination to consider them as such.

CHAPTER 125

Oil and Oil Burners

Oil.—In its broad meaning, oil is any greasy liquid and may be of animal, vegetable or mineral origin.

Mineral oil is any oil coming from the interior of the earth.

Crude oil, technically called petroleum, is the mother product or raw material just as it comes from the ground, from which the oil refinery produces all of its many products.

Oil refining is the process of separating the various grades of mineral oil contained in crude oil from the impurities therein and classifying them according to the boiling point of each grade. In practice the crude stock is put into a large vessel called a "still" and heated until all the oil, or as much of it as the refiner wants, distills out in the form of hot vapor or gas, which is afterwards condensed into a liquid state by cooling the vapor as it passes through coils surrounded by cold water. Since each commercial oil product has a different boiling or vaporizing temperature from any other, it is thus easy to break up crude and obtain in a clear refined state any of its constituents by taking out the lightest products first and then heating the residue to the boiling temperature of the next one desired.

Distillate in a broad sense is any product obtained by oil distillation. Strictly speaking the word distillate does not mean anything except that it is a clear product from an oil distillery. Those products lighter than kerosene are usually referred to, however, as distillates; those as heavy as kerosene and heavier

are usually referred to as oils, although they are distillates as much as is gasoline. Distillate oil is the proper name.

Some clear refined distillates, arranged in the order of their boiling points, are:

Benzine.—A product lighter and more carefully refined than gasoline.

Gasoline.—A refinery product composed of a mixture of the various distillates in such proportions as to keep the density between 56° and 72° Baumè.

Petrol.—A foreign trade name for gasoline.

Benzol.—A light liquid product resembling gasoline which is obtained by fractional distillation of coal. In other words, a "by product" from gas works and bee hive coke ovens.

Motor Spirits.—A commercial name for a low grade gasoline recently put on the American market.

Naphtha.—Another trade name for gasoline.

Distillate.—An engine fuel before given a commercial name.

Engine Distillate.—Trade name for kerosene too carelessly graded to be safe in lamps. (Gravity around 40° Baumè.)

Solar Oil.—Discolored, carelessly prepared kerosene.

Kerosene or Coal Oil.—A distillate heavier than gasoline and lighter than gas oil, bleached white and having a flash test high enough to pass the state oil inspector.

Gas Oil.—A distillate oil slightly heavier than kerosene and usually has an amber cast. One of the heaviest refined engine distillates.

Distillates heavier than gas oil are marketed for lubricating oil under various trade names. Those requiring the most heat to gasify and consequently coming off last are sold to lubricate hot surfaces such as engine cylinders and are known as high *fire test lubricating oils*.

Since the demand for lubricating oil is limited, only a small portion of the crude stock is worked down below the distilling points of the common engine distillates for which the refiner can get a ready market. In other words, he takes out of the crude those products his orders call for and dumps the residue into the fuel tank and sells it for fuel in the place of coal.

Some Cheap Unrefined Residual Oils.—Since these oils

are scraps from the refinery and crude oils from the different fields vary in impurities and properties and different batches of crude receive different treatment to supply the refiners' demands, seldom are two lots of fuel oil similar in composition or density.

Fuel Oil.—Any unrefined oil that will do to burn in the place of coal.

Residium.—Another name for fuel oil.

Tops.—Another name for residium.

Stove Oil.—A trade name used in the West for fuel oil.

Star Oil.—A California trade name for fuel oil.

Tar Oil.—An oil obtained from crude coal tar in the coke and gas manufacturing industry.

Holder Oil.—Oil that condenses in the gas holder tanks. A by-product from city gas plants.

Gravity of Oils.—The standard instrument for the measurement of the density of oil is the Baumè hydrometer. The gravity of oils should be taken at a temperature of 60° Fahr. A rough rule for determining the gravity at any other temperature is: *For every* 10° *Fahr. above* 60°, *substract one degree from the Baumè reading, and for every* 10° *below* 60°, *add one degree.*

Example.—If the hydrometer indicate a gravity of 27.5° B. and the temperature of the oil for this reading be 75° Fahr., the temperature then is 15° above 60°, and the correct gravity is

$$27.5° - \frac{15}{10} = 26° \text{ B.}$$

In case the hydrometer indicate a gravity of 24° B. at a temperature of 40° Fahr. Then the correct gravity will be

$$24 + \frac{60-40}{10} = 26° \text{ B.}$$

Formula for reducing Baumè reading (liquids lighter than water) to specific gravity:

$$\text{specific gravity} = \frac{140}{130 + \text{degrees Baumè}}$$

Thus:

gravity Baumè = 26 at 60° F.

or, $$\text{specific gravity} = \frac{140}{130 = 26} = .897$$

Approximate Weights of Petroleum Oil

Degrees Baumè	Degrees sp. grav.	Pounds in 1 gallon	Degrees Baumè	Degrees sp. grav.	Pounds in 1 gallon
10	1.0	8.33	43	.8092	6.74
11	.9929	8.27	44	.8045	6.70
12	.9859	8.21	45	.8	6.66
13	.9790	8.16	46	.7954	6.63
14	.9722	8.1	47	.7909	6.59
15	.9655	8.04	48	.7865	6.55
16	.9589	7.99	49	.7821	6.52
17	.9523	7.93	50	.7777	6.48
18	.9459	7.88	51	.7734	6.44
19	.9395	7.83	52	.7692	6.41
20	.9333	7.78	53	.7650	6.37
21	.9271	7.72	54	.7608	6.34
22	.9210	7.67	55	.7567	6.30
23	.9150	7.62	56	.7526	6.27
24	.9090	7.57	57	.7486	6.24
25	.9032	7.53	58	.7446	6.20
26	.8974	7.48	59	.7407	6.17
27	.8917	7.43	60	.7368	6.14
28	.8860	7.38	61	.7329	6.11
29	.8805	7.34	62	.7290	6.07
30	.8750	7.29	63	.7253	6.04
31	.8695	7.24	64	.7316	6.01
32	.8641	7.20	65	.7179	5.98
33	.8588	7.15	66	.7142	5.95
34	.8536	7.11	67	.7106	5.92
35	.8484	7.07	68	.7070	5.89
36	.8433	7.03	69	.7035	5.86
37	.8383	6.98	70	.7000	5.83
38	.8333	6.94	75	.6829	5.69
39	.8384	6.90	80	.6666	5.55
40	.8235	6.86	85	.6511	5.42
41	.8187	6.82	90	.6363	5.30
42	.8139	6.78	95	.6222	5.18

Example.—What is the Baumé reading for oil whose specific gravity is .8092?

$$140 \div .8092 - 130 = 43° \text{ Baumé}$$

As the gravity of the oil varies, naturally the density changes, and while the light oils are thin and will flow readily, the heavy oils or those below 20° Baumé are thick and flow with difficulty, especially in cold weather.

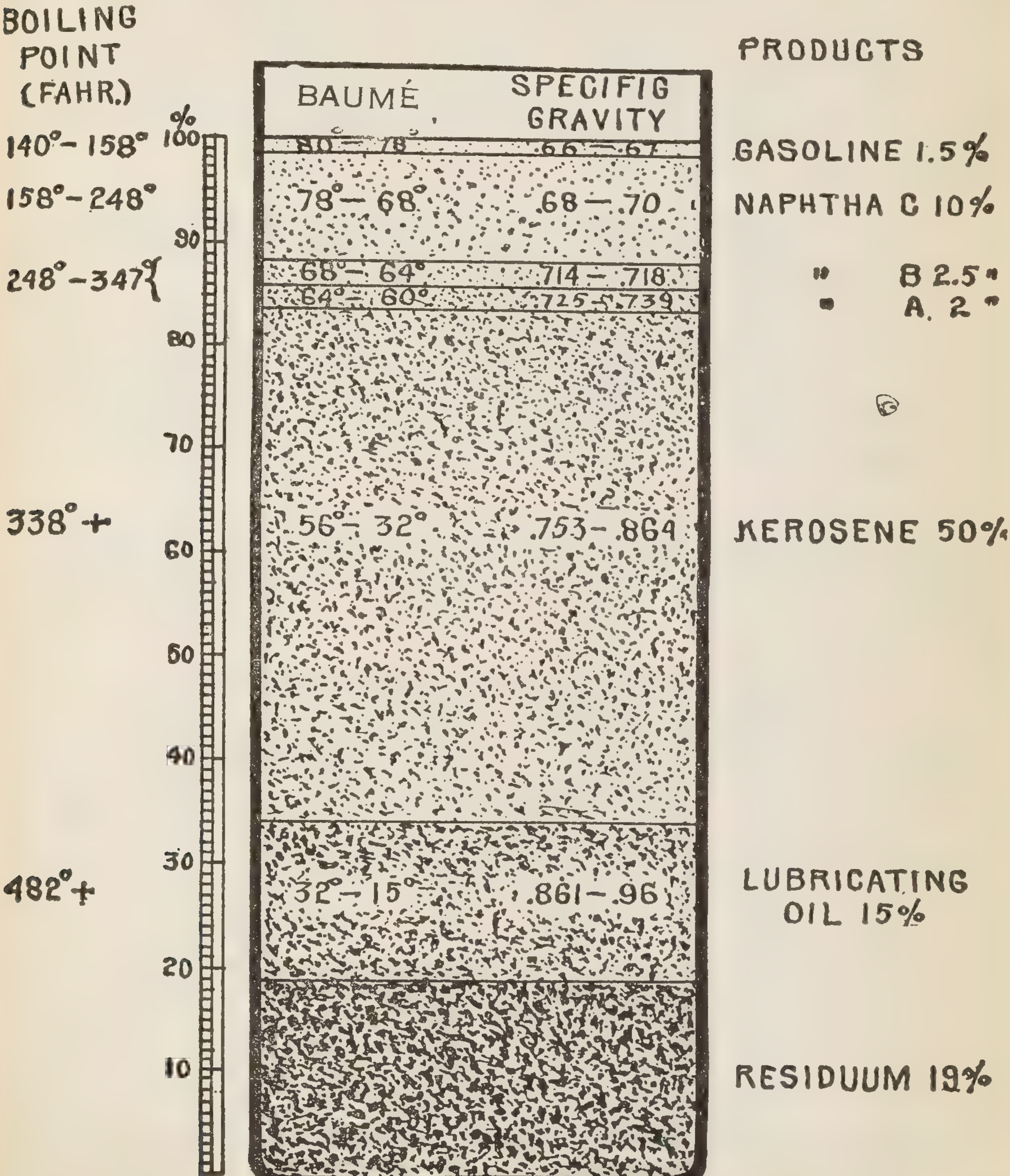


FIG. 8,867.—The various products obtained by the distillation of petroleum. *In the process* of distillation these products are separated according to their boiling points as indicated.

Heating Value of Oils.—In considering the relative costs of fuels, the actual heat units (*B.t.u.*) per dollar should be the basis of comparison. Coal is bought by all careful purchasers on a *B.t.u.* basis and fuel oil should be purchased by the same standard. Depending on the *B.t.u.* value, from three to three and one-half barrels of oil do the work of one ton of best quality coal.

B.t.u. means *British thermal unit,* and is *the unit by which the calorific value or heat value of any fuel is measured. One B.t.u.* is *that amount of heat required to raise one lb. of water 1° Fahr.*

Example.—One U. S. gallon of oil contains approximately 144,000 *B.t.u.* Therefore, if this gal. of oil were burned under theoretically perfect conditions, and all the heat produced could be transferred to 144,000 lbs. of water, the water would rise in temperature 1° Fahr. If there were 14,400 lbs. of water, it would rise in temperature 10° Fahr.

The table given below shows the amounts of the different fuels listed required to equal each other on the basis of heat units.

Amounts of Different Fuels for Equal Heat Units

Oil Gallon	Coal Pounds	Natural Gas Cubic Feet	Coal Gas Cubic Feet	Coke Oven Cars Cubic Feet	Bituminous Producer Gas Cubic Feet	Anthracite Producer Gas Cubic Feet	Total B. T. U.
1.	12.	144	230	243	986	1035	144,000
167.	2000.	24000	38400	40500	164000	173000	24,000,000
6.95	83.5	1000	1600	1690	6850	7180	1,000,000
4.34	52.1	625	1000	1055	4280	4500	625,000
4.1	49.3	529	945	1000	4050	4260	592,000
1.02	12.2	146	235	248	1000	1055	146,000
.97	11.6	139	222	234	953	1000	139,000

NOTE.—***The above table*** is figured on basis of coal, 12,000 *B.t.u.* per lb.; oil, 144,000 *B.t.u.* per U. S. gal.; natural gas, 1,000 *B.t.u.* per cu. ft.; coal gas, 625 *B.t.u.* per cu. ft.; coke oven gas, 592 *B.t.u.* per cu. ft.; bituminous producer gas, 146 *B.t.u.* per cu. ft.; anthracite producer gas, 139 *B.t.u.* per cu. ft.

Table of Calorific Values of Various Oils

Beaume°	Specific Gravity	Pounds in a Gallon	Calculated B. T. U. per Pound	Calculated B. T. U. per Gallon	Remarks
14	.9722	8.10	18810	152361	Mexico, California, Texas and Kansas Crudes Fuel Oil
15	.9655	8.05	18850	151743	
16	.9589	7.99	18890	150931	
17	.9523	7.94	18930	150304	
18	.9459	7.88	18970	149484	
19	.9395	7.83	19010	148848	
20	.9333	7.78	19050	148209	
21	.9271	7.73	19090	147506	
22	9210	7.68	19130	146918	
23	.9150	7.63	19170	146267	
24	.9090	7.58	19210	145612	
25	.9032	7.54	19250	145145	
26	.8974	7.49	19290	144482	
27	.8917	7.44	19330	143815	
28	.8860	7.39	19370	143144	Kansas, Indian Territory and Illinois Crudes, Penn'a Fuel, California Refined Fuel Oil
29	.8805	7.34	19410	142469	
30	.8750	7.29	19450	141790	
31	.8695	7.25	19490	141303	
32	.8641	7.21	19530	140811	
33	.8588	7.16	19570	140121	
34	.8536	7.12	19610	139623	
35	.8484	7.07	19650	138926	
36	.8433	7.03	19690	138421	
37	.8383	6.99	19730	137913	Ohio, Penn'a and West Virginia Crude California and Kansas Refined
38	.8333	6.95	19770	137402	
39	.8284	6.91	19810	136887	
40	.8235	6.87	19850	136370	
41	.8187	6.83	19890	135849	
42	.8139	6.80	19930	135524	
43	.8092	6.76	19970	134997	
44	.8045	6.72	20010	134467	
45	.8000	6.68	20050	133934	
46	.7954	6.64	20090	133398	Kerosene and Gasoline
47	.7909	6.60	20130	132858	
48	.7865	6.57	20170	132517	
49	.7821	6.53	20210	131971	
50	.7777	6.49	20250	131423	

NOTE.—The above table of calorific values was calculated using the formula

$$B.t.u. = 18{,}650 + 40\ (\text{Baumé} -)10$$

which was derived by H. C. Sherman and A. H. Kopff in a paper in the Journal of the American Chemical Society, October, 1908.

Heat Value of Pure Oils of Different Gravities

Degrees (Baumé.)	Specific gravity	Weight per gallon	B.t.u. per pound	B.t.u. per gallon
10	1.0000	8.33	18280	152,272
12	.9859	8.21	18400	150,252
14	.9722	8.10	18520	148,033
16	.9589	7.99	18640	145,987
18	.9459	7.88	18760	143,927
20	.9333	7.77	18880	141,853
22	.9211	7.67	19000	139,956
24	.9091	7.57	19120	138,047
25	.9032	7.52	19180	137,088

Viscosity of Oils.—The viscosity of an oil is a measure of its fluidity, usually determined by Redwood's viscometer, and is expressed in seconds. The number of seconds show the time required for a given amount of oil to flow through the same sized orifice.

Viscosity has an important bearing on the design of fuel oil apparatus and the table shows why it is important to heat the oil.

Viscosity of Fuel Oil

Temperature	Viscosity	Temperature	Viscosity
40° F.	5,096 Seconds	80° F.	335 Seconds
50° F.	2,227 Seconds	90° F.	210 Seconds
60° F.	1,285 Seconds	100° F.	145 Seconds
70° F.	539 Seconds	110° F.	95 Seconds

Tar.—This is a dark colored product obtained in the destructive distillation of peat, wood, coal and other materials of organic origin.

The tar used for fuel, and commonly known as tar, is coal tar. It can be used as satisfactorily for fuel as oil, and has the same advantages. However, it must be considered and handled with the same type of equipment and burners as heavy gravity oil.

It is slightly heavier than crude oil and has a comparatively low flash point. In burning, it should be heated only to a temperature which makes it sufficiently fluid, and any furnace suitable for crude oil is in general suitable for water gas tar. Care should be taken where this fuel is used to install a suitable apparatus for straining it before it is fed to the burner.

It would appear from experiments that such a combination gives satisfactory results from the standpoint of both capacity and efficiency, if the two fuels are burned in separate furnaces. Satisfactory results cannot ordinarily be obtained when it is attempted to burn oil fuel in the same furnace as the primary fuel, as it is practically impossible to admit the proper amount of air for combustion for each of the two fuels simultaneously.

Heat Absorptive Power of Boilers.—Tests made by the U. S. Navy Department with fuel oil show that the heat absorptive power of boilers is very great and that boilers can be pushed with little drop in efficiency far above their normal rating.

The evaporation per sq. ft. of heating surface has been increased from 3 lbs. of water from and at 212° to 15 lbs. of water—500 per cent. of the normal rating—with a drop in efficiency of only 10 per cent. These results are astonishing and show the possibilities of small boiler installations when using oil fuel. The following table was taken from one of the Navy Department tests:

Heat Absorptive Power of Boilers—Sq. Ft.

Pounds of oil burned per square foot of Heating Surface per hour	0.20	0.40	0.60	0.80	1.00	1.10
Evaporation F & A 212° per lb. of oil	15.40	15.15	14.50	14.00	13.50	13.40
Evaporation F & A 212° per square foot of Heating Surface per hour	3.10	6.00	8.70	11.20	13.50	14.70
Pounds of oil per cubic foot of Combustion space	1.30	2.65	4.00	5.30	6.70	7.30
Boiler Efficiency %	77.50	76.50	73.00	70.00	68.00	67.25

Oil Pressure and Preheating.—It is necessary that fuel oil to be burned in any type of burner be brought to the burners under pressure. Variation in the oil pressure should be avoided, for it will cause inefficient atomization and imperfect combustion. Also, in order to obtain the best results, the oil should be preheated not to exceed its flash point. This decreases the viscosity of the oil, greatly increases the quality of the atomization and cuts down the amount of air or steam required for atomization. Conclusion No. 7 from the report of the Naval Liquid Fuel Board covers the question of preheating in this manner:

"In order to provide a uniform supply of oil to the burners the oil should be heated by some simple means. It can be expected that the burners will be operated with much more satisfaction when the oil is thus heated."

This report was drawn up by a board of naval engineers after about two years of experimenting with and studying the conditions for burning fuel oil.

Storage of Oil.—The size of oil installation and amount of fuel to be used will control the size of oil storage unit or units necessary.

As a general rule, however, sufficient tankage should be available to avoid demurrage charges.

In the average size installations horizontal cylindrical tanks are used, buried under ground near an available railroad siding so that cars can be unloaded by gravity.

In larger installations, concrete basins under ground or vertical cylindrical tanks above ground are used; in some cases such tanks hold 100,000 gallons or more. The standard outlet connection from tank cars is 2½ in. pipe. Suitable piping must be installed to carry oil from cars to tanks connected at the tank with flexible oil tight hose. Care should be taken when disconnecting hose at tank that all oil has drained from tank and hose in order to prevent waste. In cold weather with light oils and at all times

with heavy oils it is necessary to heat the oil in the car to make it flow freely.

Tank cars are generally provided with steam coils and arrangements should be made for steam connection near the railroad siding where cars are unloaded.

It is not necessary and is wasteful to heat all of the oil in the storage tank before it is pumped to burners. A small steam coil should be placed in storage tank around the suction line. This heats the oil so that it flows freely into the suction line. Any further heating should be done by pumping systems or heaters after oil has left the storage tanks.

In cases where the oil contains water it should be passed through a filtering tank before going to the burners. In this filtering tank the water settles to the bottom and can be easily drawn off. The oil should be heated before going to the filtering tank, as any water in the oil is more easily separated out of hot oil than cold oil; and heated oil, being limpid, offers less resistance to freeing the water. Also, there is a greater expansion of oil than water under the action of heat, and the water gains a relatively greater specific gravity as a result.

Requirements for Burning Oil Fuel.—There are several conditions which must be fulfilled to properly burn oil:

1. Its atomization or vaporization must be thorough.

   This requirement is met by the selection of a proper burner.

2. When atomized it must be brought into contact with the requisite quantity of air for its combustion, and this quantity must be at the same time a minimum to obviate loss in stack gases.

3. The mixture must be burned in a furnace where refractory material radiates heat to assist in the combustion, and the furnace must stand up under the high temperatures developed.

4. The combustion must be completed before the gases come into contact with the heating surfaces or otherwise the flame will be extinguished, possibly to ignite later in the flue connection or in the stack.

5. There must be no localization of the heat on certain portions of the heating surfaces or trouble will result from overheating and blistering.

The foregoing requirements are fulfilled:

1. By the selection of a proper burner.

2. By properly introducing the air into the furnace, either through checker-work under the burners or through openings around them, and by controlling the quantity of air to meet variations in furnace conditions.

3. By installing a furnace so designed as to give a sufficient area of heated brick work to radiate the heat required to maintain a proper furnace temperature.

4. By giving ample space for the combustion of the mixture of atomized oil and air, and a gas travel of sufficient length to insure that this combustion be completed before the gases strike the heating surfaces.

5. By the adoption of a suitable burner in connection with the furnace, meeting the other requirements. A burner must be used from which the flame will not impinge directly on the heating surface and must be located where such action cannot take place. If suitable burners properly located be not used, not only is the heat localized with disastrous results, but the efficiency is lowered by the cooling of the gases before combustion is completed.

Oil Burners.—The term oil burner may be defined as an erroneous name for *any device wherein oil fuel is atomized or vaporized* ***previous*** *to ignition.*

The main function of a burner is **to atomize the oil,** that is, break it up into a large number of very small particles and blow it into the furnace as a very fine mist, practically a gas, ready for immediate and complete combustion.

A properly constructed burner will show no dark stream of oil entering the furnace from its tip. Instead the oil will emerge in an almost imperceptible spray or vapor.

There is a great variety of burners and they may be classified in several ways, as

1. With respect to the gasifying process, as:

   a. Vaporizers.
   b. Sprayers

2. With respect to the atomizing agent, as:

a. Air;
b. Steam.

3. With respect to the method of spraying, as:

a. Outside mixing { drooling; atomizer; projector; centrifugal;

b. Inside mixing { chamber; injector; centrifugal.

What is an outside mixing burner?

FIG. 8,868.—***Drooling*** burner. The oil to be atomized passes out and down from the upper passage, where it meets air or steam issuing from the lower passage and being caught by the rapidly escaping and expanding air or steam is thoroughly sprayed.

One in which oil and atomizing agent meet outside the burner.

Drooling Burner.—The oil supply simply drools or oozes out, at the orifice over and on to the steam or air jet as in fig. 8,868. *In operation*, as the steam or air issues forth it expands within the layer or film of oil which is being carried into the furnace.

Atomizer Burner.—The oil is brought through an orifice from which it is swept off by a brush of steam or air as in fig. 8,869. It is the principle made use of in the ordinary cologne spraying devices.

Atomization is best accomplished by using steam or compressed air. Where steam or compressed air is not available, the atomization can be accomplished by proper spray tip nozzle, in which case it is doubly important that the oil or tar be

heated. When steam is used for atomization, every precaution should be taken to insure its delivery at the burners as dry as possible. Moisture in the steam increases the fuel consumption, as this water must naturally be evaporated and raised to the temperature of the furnace.

High Pressure Atomizing Burner.—The type of burner using steam or compressed air for atomization and depending for combustion on air drawn through the burner opening by the velocity of the atomized oil, is commonly known as a high pressure burner.

Low Pressure Atomizing Burner.—The type of burner using a spray tip for atomization and low pressure air for combustion is commonly known as a low pressure burner.

High and Low Pressure Atomizing Burner.—The difficulties arising

FIG. 8,869.—*Atomizer* burner. The oil is brought through an orifice directly across the path of the jet of air or steam and is "brushed" off by the latter and sprayed.

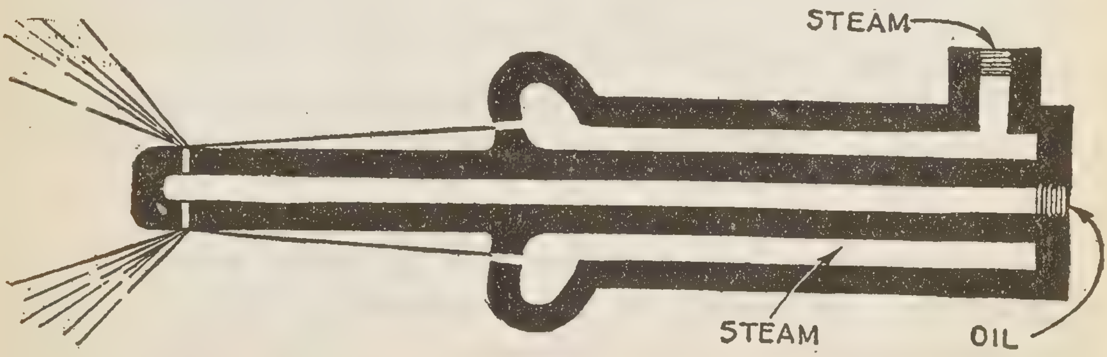


FIG. 8,870.—*Projector* burner. The oil is pumped to the oil orifice and caught by the air or steam jets which are located some distance back of the oil orifice.

from trying to operate efficiently a low pressure burner on heavy oils or tar led to the first development of the combination high and low pressure type of burner. This burner uses compressed air or steam for atomization and low pressure air for combustion, and operated with maximum efficiency on both heavy and light oil or tar, making it possible to standardize equipment no matter what oil is used. The Tate-Jones burner is an example of this type of burner.

Projector Burner.—The oil is pumped to the oil orifice and from there is caught by a passing gust of steam and is blown off as in fig. 8,870.

Outside Centrifugal Burner.—The oil is lead through the hollow

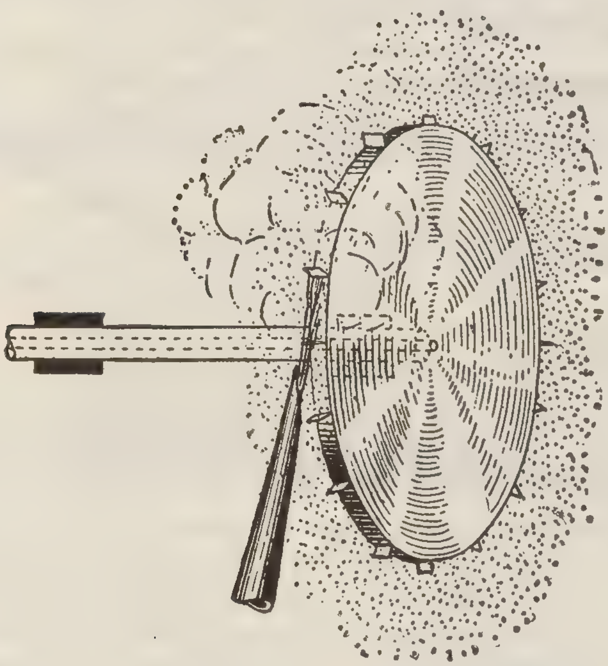


Fig. 8,871.—Outside centrifugal burner.

spindle of a disc, which is rotated at high speed by a jet of steam acting on vanes attached to the circumference of the disc, and, overflowing onto the disc at its center, is hurled off the disc by centrifugal force and ignited by a torch, producing a ring of flame as in fig. 8,871.

What is an inside mixing burner?

One in which the oil and atomizing agent meet inside the burner.

Inside Centrifugal Burner.—In the end of the pipe near the nozzle is placed a series of slanting vanes as shown in fig. 8,872 which deflect the oil and break it up into a number of currents, each of which has a whirling motion.

Injector Burner.—The principle here employed is similar to the injector used for boiler feeding. *In operation*, the steam and oil mingle within cone

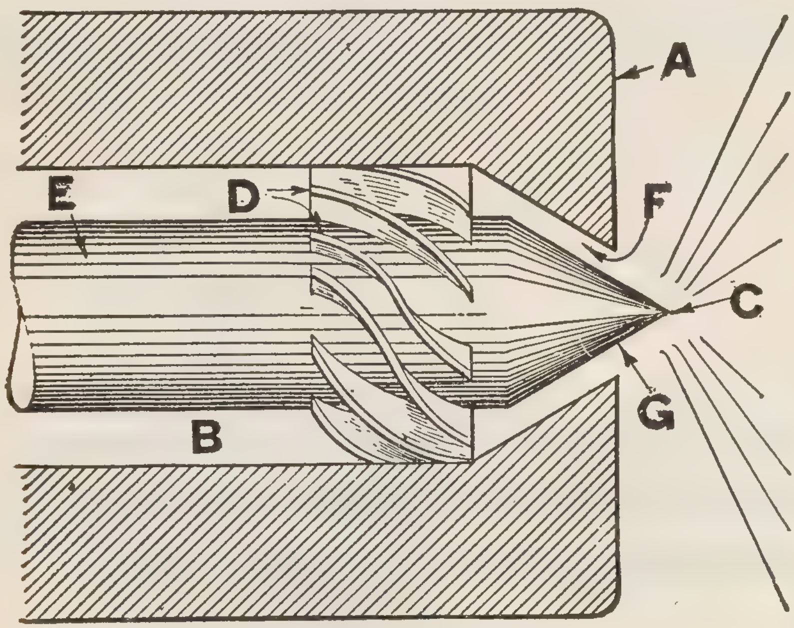


FIG. 8,872.—Inside centrifugal burner. ***In construction,*** at the end of the pipe A, that conveys the oil, the oil passage B, is tapered down to the opening C, through which the oil is discharged. The series of slanting vanes D, on the rod E, deflect the oil and break it up into a number of currents, each of which has a whirling motion as it enters the space F, around the end G, of the rod. The centrifugal force due to the whirling motion given by the vanes causes the spray to spread on leaving the burner as shown by the diverging lines.

FIG. 8,873.—***Injector*** inside mixing burner.

shape passages and, as a mixture, pass through a contracted nozzle and then outward through a reversed flaring cone, as in fig. 8,873.

Chamber Burner.—The oil and steam are more or less mingled within the body of the burner as in fig. 8,874 and pass out from the tip of nozzle as a mixture, and then, owing to the expansion of the steam, the oil is rapidly broken into minute particles.

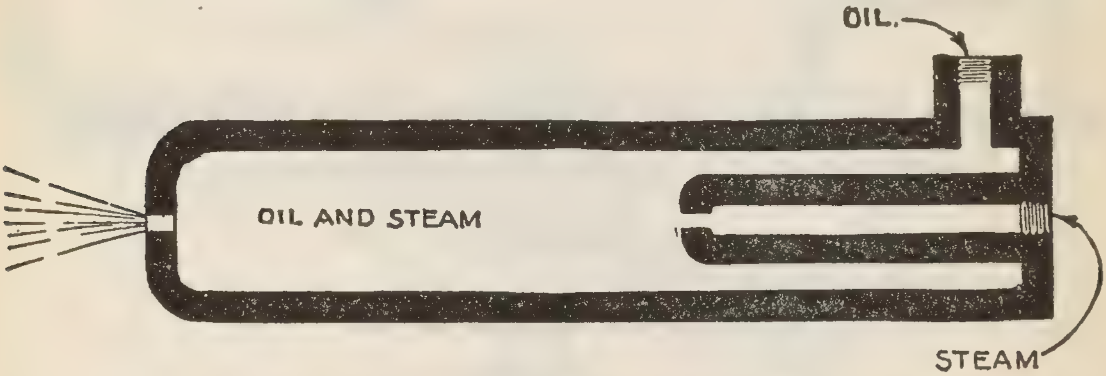
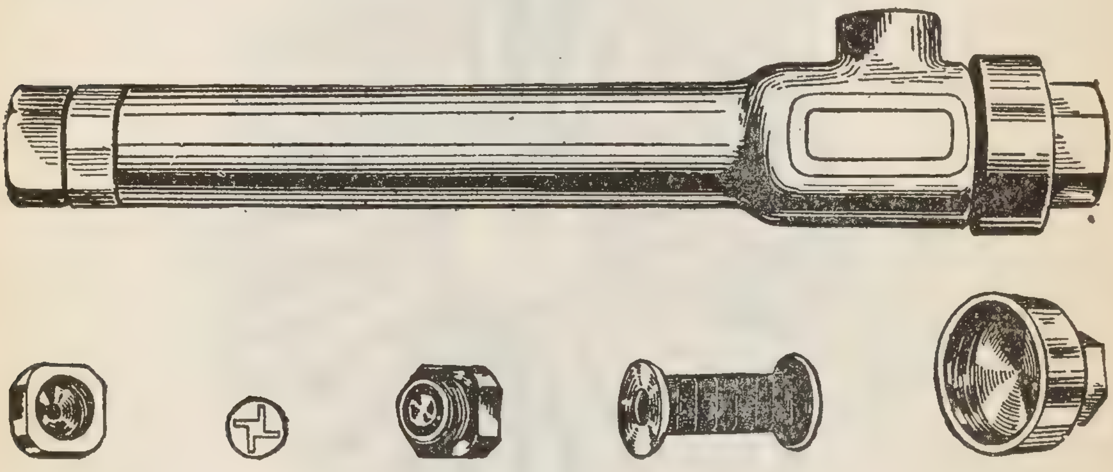
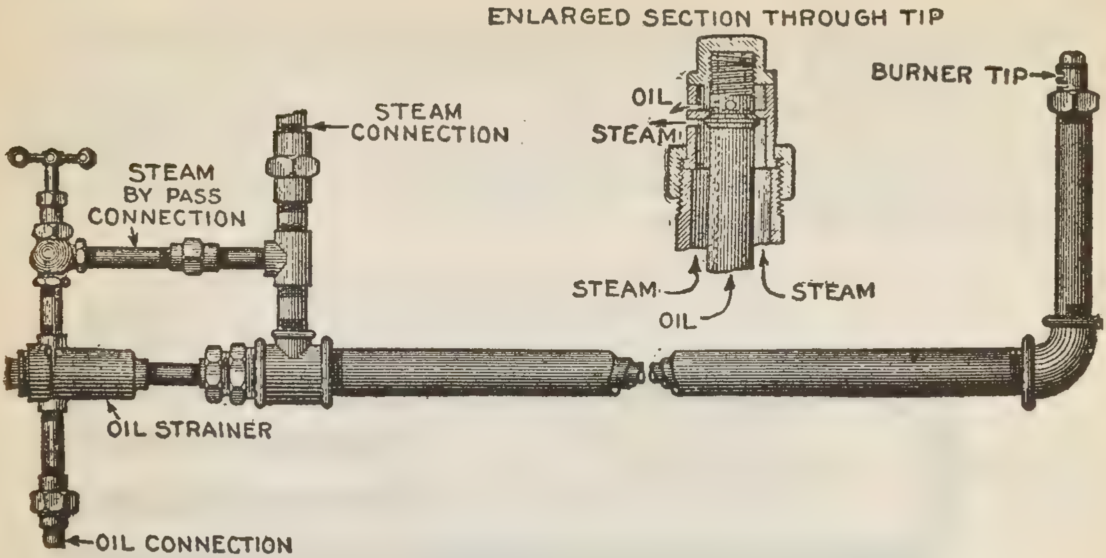


FIG. 8,874.—***Chamber*** burner. The oil and steam are more or less mixed before issuing from the burner. With this burner the oil is heated before leaving the burner.



FIGS. 8,875 to 8,880. Peabody burner and parts. Oil is delivered under pressure to an annular channel cut into the face of a nozzle upon which is screwed a tip having a very small central chamber communicating with a discharge orifice. Between the nozzle and the tip a thin washer or chamber disc is inserted and held firmly in place. This has a hole in the center corresponding with the diameter of the central chamber of the tip, and small slots or ducts, extending tangentially from the edges of the central opening outward toward the periphery of the washer long enough to overlap the annular channel of the nozzle and put it in communication with the central chamber. The effect is that, when the burner is assembled with the washer in place, oil is delivered through the ducts tangentially to the central chamber where it rapidly revolves and almost immediately is discharged through the orifice in the tip. The burner is connected as shown in fig. 8,881.



FIGS. 8,881 and 8,882. Peabody burner and pipe connections.

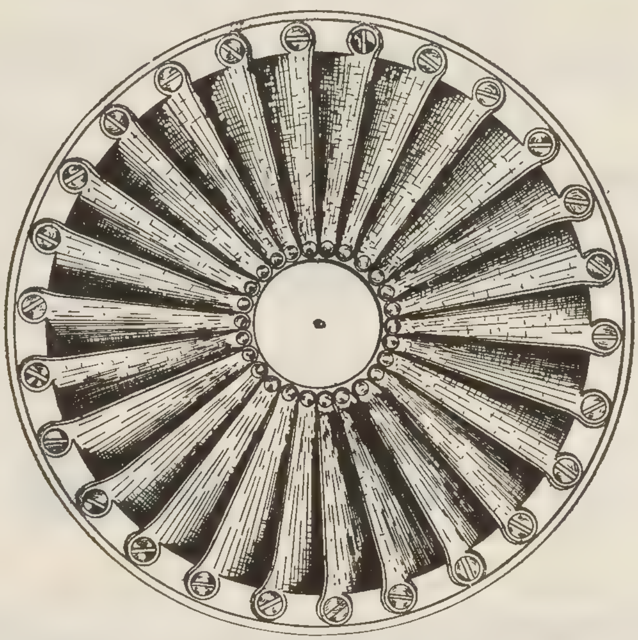


FIG. 8,883.—Peabody and Irish impeller or air register. ***In a paper*** read before the Society of Naval Architects and Marine Engineers, Mr. Peabody says: "Great delicacy is required in introducing the air for combustion, very slight changes affecting the results in unsuspected ways, and while almost any method may result in smokeless combustion, maximum economy and capacity can be secured only by careful and intelligent design. It is not necessary to give the air a whirling motion but, judging from our rather exhaustive experiments, better gas analyses are secured, lower air pressures are required, and less refinement of adjustment is needed if the air be brought into contact with the oil spray with the right sort of a twist. We have found the impeller plate, illustrated on this page, most effective, in accomplishing this mixture, and our most satisfactory results have been obtained with it."

So Called Mechanical Burners.—These burners are properly termed centrifugal burners. In these burners the oil is given a whirling motion, preferably, within the burner tip. This is done either by forcing the oil through a passage of helical form or by delivering it tangentially to a circular chamber from which there is a central outlet. The oil is fed to these burners under a pressure which varies with the make of the burner and the rates at which individual burners are using oil.

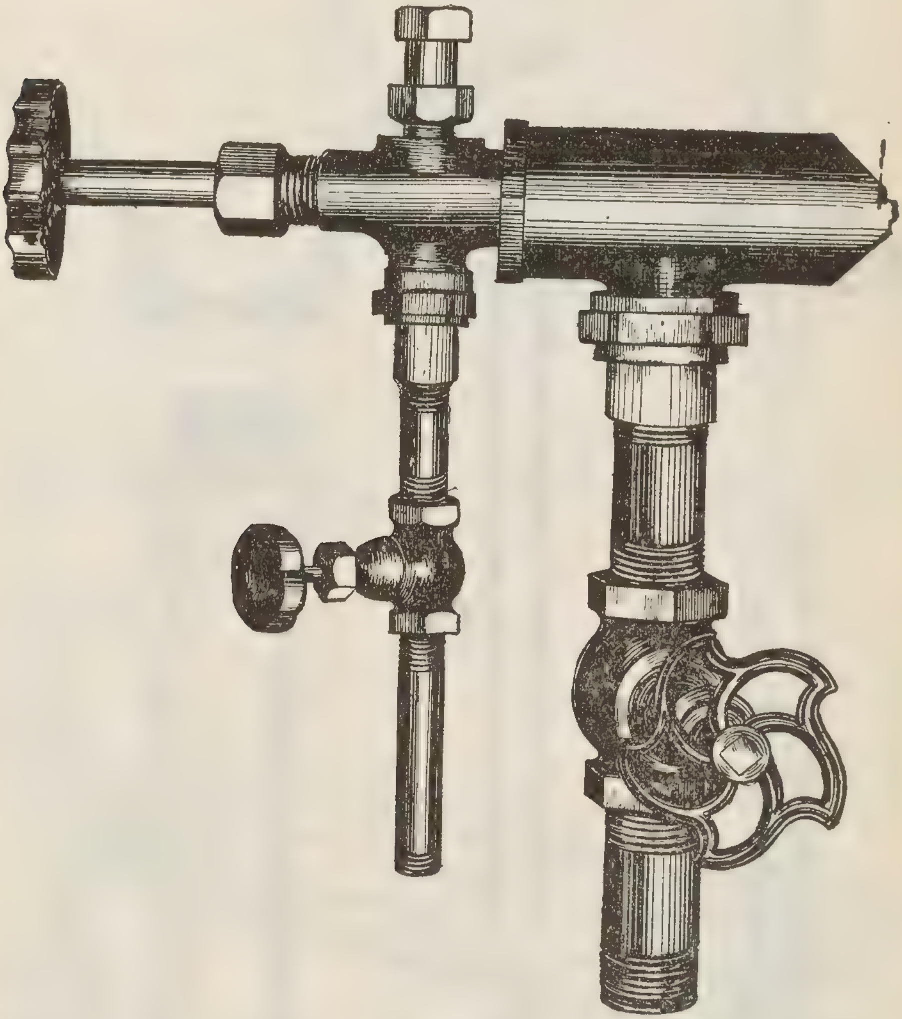
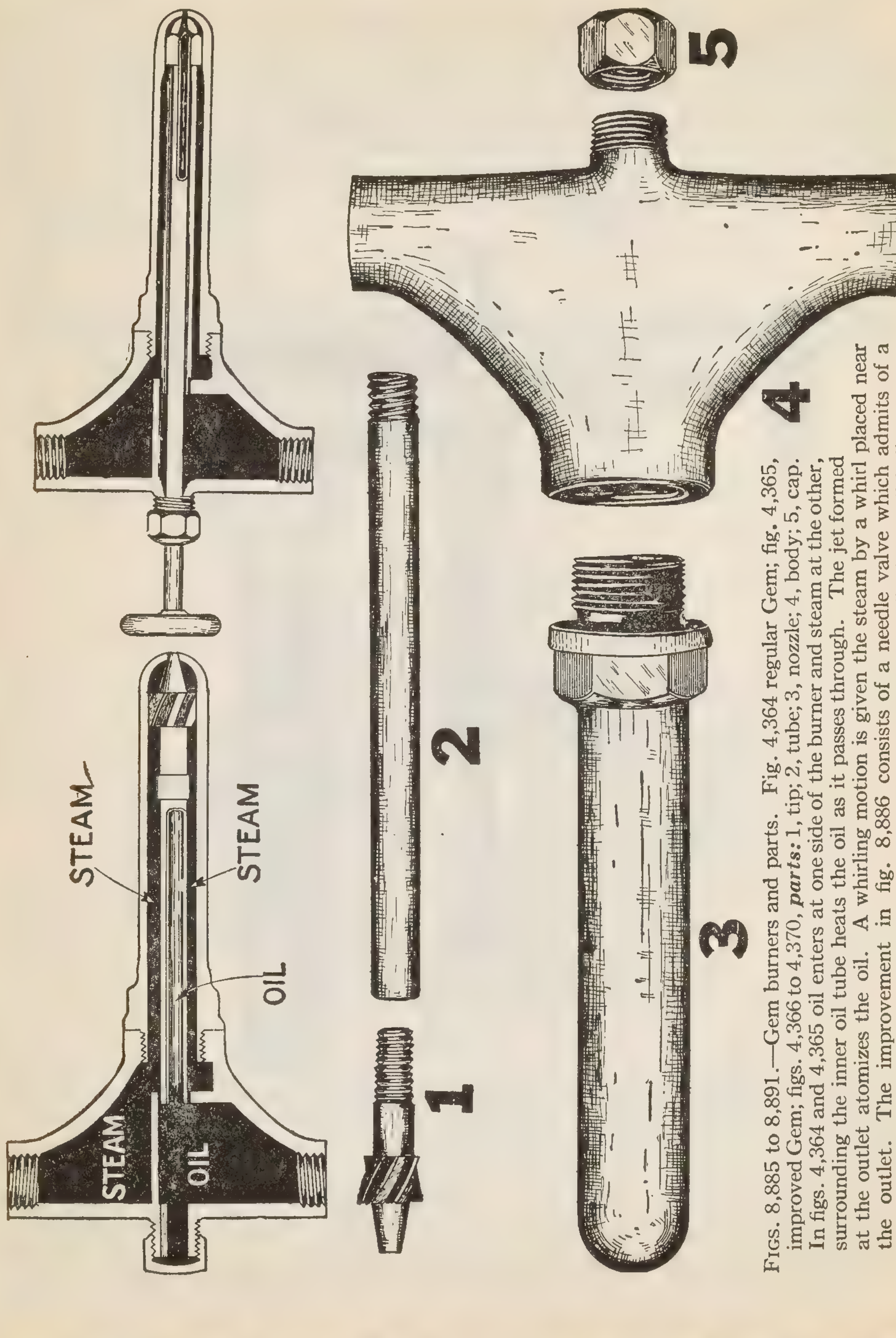


FIG. 8,884.—Monarch all brass burner. It is a combination burner for either "high or low" pressure, and is adjusted by the center lock nut working backward or forward. The feed pipes are regulated with standard valves and the oil adjusted by needle valve.

The oil particles fly off from such a burner in straight lines in the form of a cone rather than in the form of a spiral spray, as might be supposed.

Where, in the spray burners, air is ordinarily admitted through a checker



FIGS. 8,885 to 8,891.—Gem burners and parts. Fig. 4,364 regular Gem; fig. 4,365, improved Gem; figs. 4,366 to 4,370, ***parts:*** 1, tip; 2, tube; 3, nozzle; 4, body; 5, cap. In figs. 4,364 and 4,365 oil enters at one side of the burner and steam at the other, surrounding the inner oil tube heats the oil as it passes through. The jet formed at the outlet atomizes the oil. A whirling motion is given the steam by a whirl placed near the outlet. The improvement in fig. 8,886 consists of a needle valve which admits of a closer regulation of the oil supply. This burner is adapted especially for small boilers.

work under the burner proper, with the mechanical burner, it is almost universally admitted around the burner.

Steam Consumption of Burners.—The Bureau of Steam Engineering, U. S. Navy, made in 1901 an exhaustive series of tests of various oil burners that may be considered as representing, in

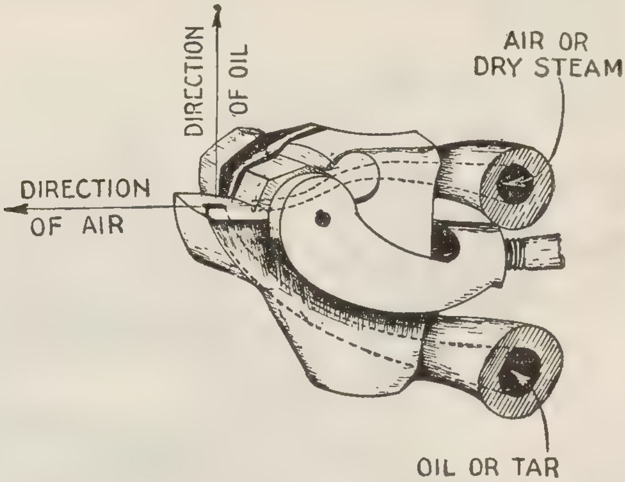


FIG. 8,892.—***Best*** high pressure type burner, for light or heavy oil, or tar. ***In operation,*** the air or steam meets the oil at right angles. By releasing the set screw in yoke and raising the lips, any obstruction that might find its way through the air line can be blown out.

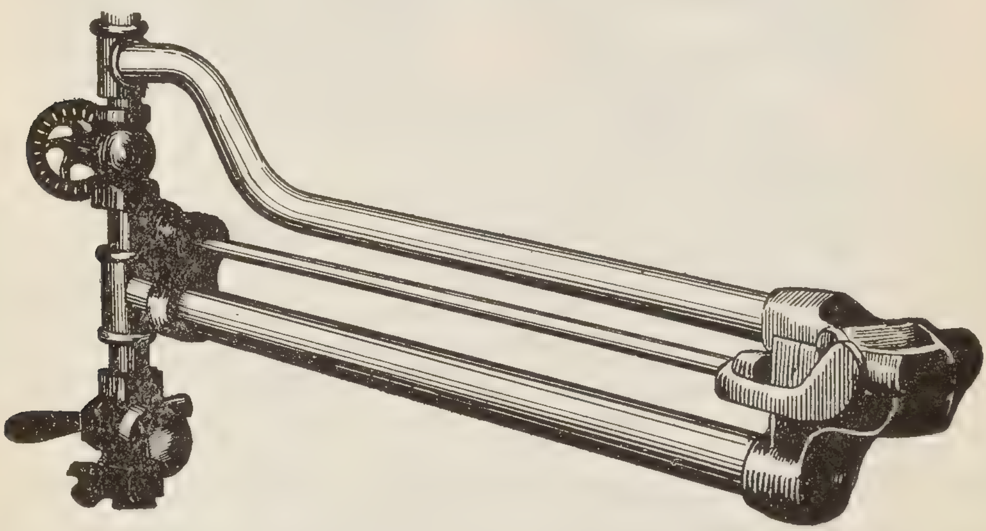


FIG. 8,893.—***Best*** burner mounted for boiler. The burner is connected to piping of sufficient length to go through the front setting of boiler. By means of the by pass valve any foreign substances that may enter the oil pipes can be blown out. The atomizer lip is hinged and held tight against the body of the burner, but means are provided for raising the lip to blow out the atomizer pipe in case any foreign substance such as scale, red lead, etc., should lodge therein. This can be accomplished without removing the burner from boiler.

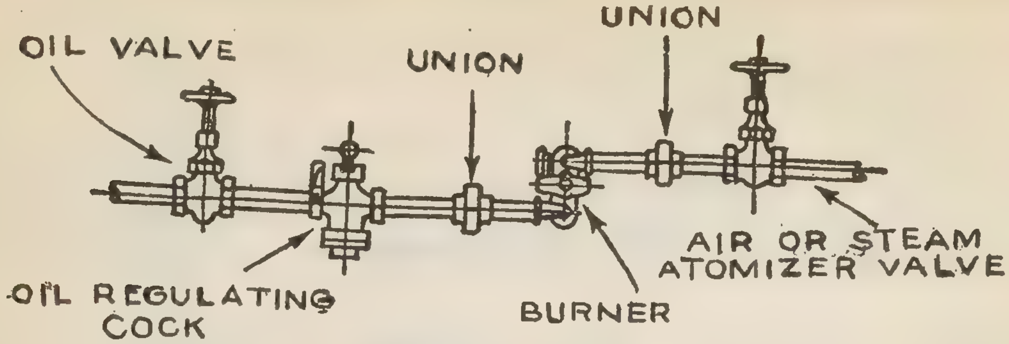


FIG. 8,894.—Correct method of connecting ***Best*** atomizer valve (air or steam), also regulating cock and oil cut out valve.

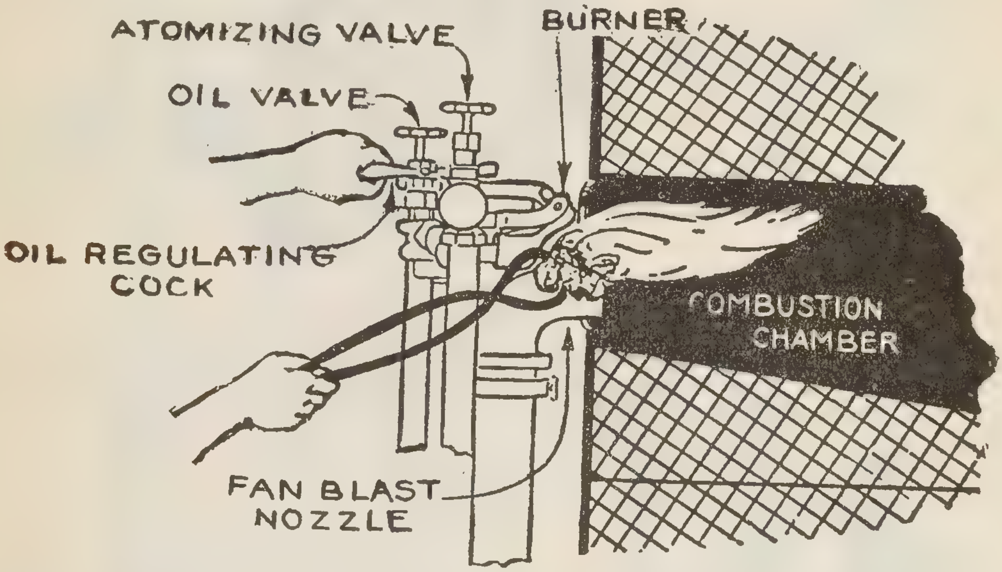
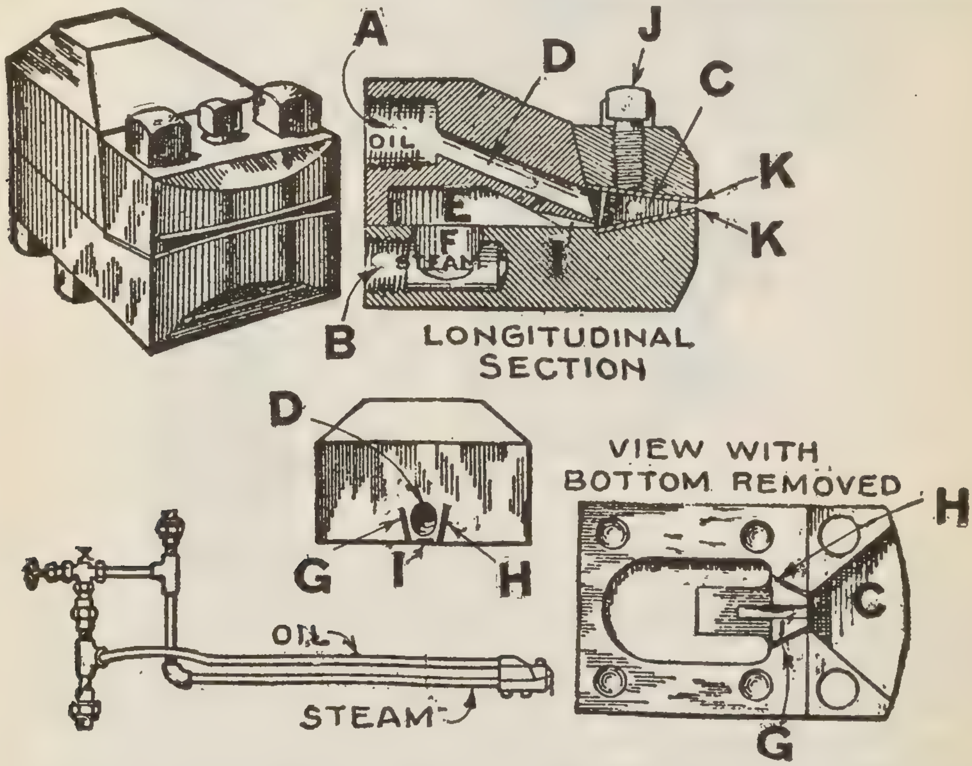


FIG. 8,895.—Correct method of starting ***Best*** oil burner. Open furnace door and keep it open until the brick work shows red. Saturate well a piece of cotton waste as large as a fist with kerosene, light it and hold with pair of tongs under nose of burner. Open atomizer valve slightly. As the flame from the burning waste draws into the combustion chamber, open full the globe valve on the oil line then carefully turn on the oil by means of the oil regulating cock. Always be sure that there is flame from the burning waste entering the combustion chamber until the combustion chamber is above the igniting temperature of the fuel, after which the furnace can be heated to the required temperature by turning on more oil and air through the burner, also be feeding blast air through the blast nozzle above referred to. Be careful not to feed too much air or it will not only cool down the furnace, but will scale or oxidize the metal. Control oil supply so that no smoke is emitted from furnace. A clear heat should be kept in furnace, which is obtained either by cutting off a little oil or adding more air, preferably at blast nozzle, as blast air is cheaper than compressed air. After furnace is at required heat, no flame should appear at the doors or waste gas vents in the top furnace, save a green haze, which is simply the consumed gases passing away. Never allow any obstruction to stop up the vents in top of furnace. The deflection air blast simply keeps the heat from the operator, also helps to retain it in the furnace. Blast air from 2 oz. to 8 oz. is sufficient. Dry steam or compressed air of from 15 lbs. up is used for atomizing the fuel. Oil pressure in all cases must be less than that of the atomizing agent. Tar or heavy oil should always be heated by means of a steam coil in the storage tank. Never regulate oil with a globe valve but with an oil regulating cock.

so far as the performance of the burners themselves is concerned, the practice of that time. These tests showed that a burner utilizing air as an atomizing agent, required for compressing the air from 1.06 to 7.45 per cent of the total steam generated, the average being 3.18 per cent. Four tests of steam atomizing



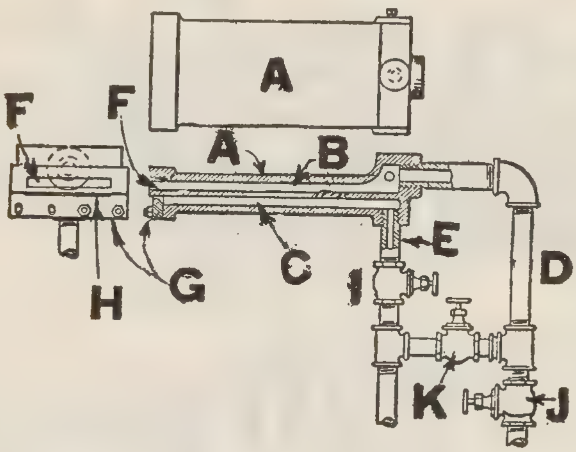
FIGS. 8,896 to 8,900.—***Hammel*** inside mixing oil burner. ***In operation,*** oil enters at A, flows through D, into the mixing and atomizing chamber C; steam enters at B, passes through F, E, and then through three small slots, G. H. and I, into mixing chamber C, where it meets the oil, and as these small steam jets cut across the oil stream at an angle, the energy of the steam is fully utilized and the burner requires only about 2 per cent or less of the amount of steam generated by the boiler, the heavy hydrocarbons are completely atomized, the light hydrocarbons are vaporized, and the completed mixture issues from the burner and ignites like a gas flame.

burners showed a consumption of 3.98 to 5.77 per cent of the total steam, the average being 4.8 per cent.

Improvement in burner design has largely reduced the steam consumption though to a greater degree in steam than in air atomizing burners. Recent experiments show that a good steam atomizing burner will require approximately 2 per cent of the total steam generated by the boiler operated at or

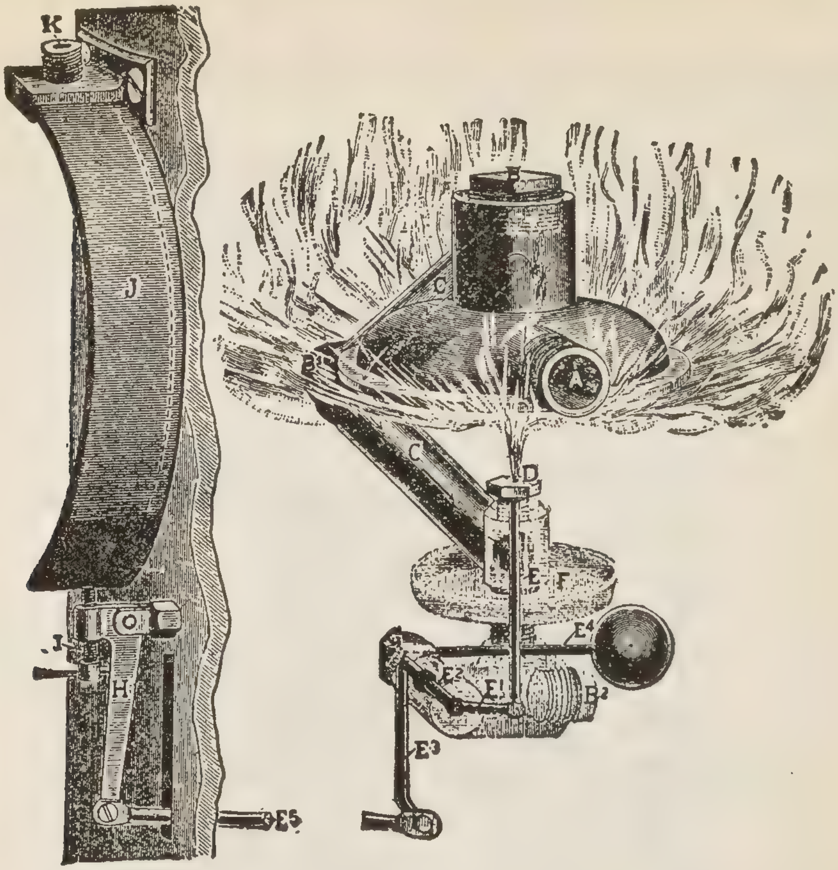
about its rated capacity. This figure will decrease as the capacity is increased and is so low as to be practically negligible, except in cases where the question of loss of feed water is all important.

There are no figures available as to the actual steam consumption of mechanical atomizing burners but apparently this is small if the requirement be understood to be entirely apart from the steam consumption of the apparatus producing the forced blast.



FIGS. 8,901 to 8,903.—*Booth* oil burner with pipe connections. The body of the burner consists of a box-shaped casting A, that is set horizontally. It contains two passages, B and C, oil being admitted to the former through the pipe D, and steam to the latter through the pipe E. The oil flows outward through the wide, shallow slot F, at the tip of the burner and drools downward across the end. An adjustable steel plate G, is bolted across the steam orifice. This plate has a long notch cut in the top edge, forming the outlet H, for the steam, and on the inside it is beveled so as to direct the steam upward toward the orifice. The escaping steam sweeps along the under side of the burner tip, and in expanding, sprays the oil that runs down from the upper slot. The bolts that hold the plate G, in place, pass through long vertical slots in the plate, and this construction allows the plate to be moved up or down to give the desired depth of slot H. This adjustment, of course, is made when the burner is disconnected and not in use. The arrangement of the piping is simple. The supply of steam is brought to the burner through the pipe E, the flow being regulated by the valve I. In the same way a valve J, in the oil line D, is used to control the rate of flow of the oil. Between the oil pipe and the steam pipe is inserted a short connection fitted with a valve K. This serves as a by pass to admit steam to the oil passage when it becomes necessary to clean out the passage. The oil valve J, and the steam valve I, are first closed and then the by pass valve K, is opened. The steam rushes through the oil passage, and its heat and its cutting action together scour the passage clean. The steam passage may be cleaned by removing the plate G, completely, and allowing steam to blow through at full pressure. The passages in the burner are straight and fairly large to avoid frequent clogging.

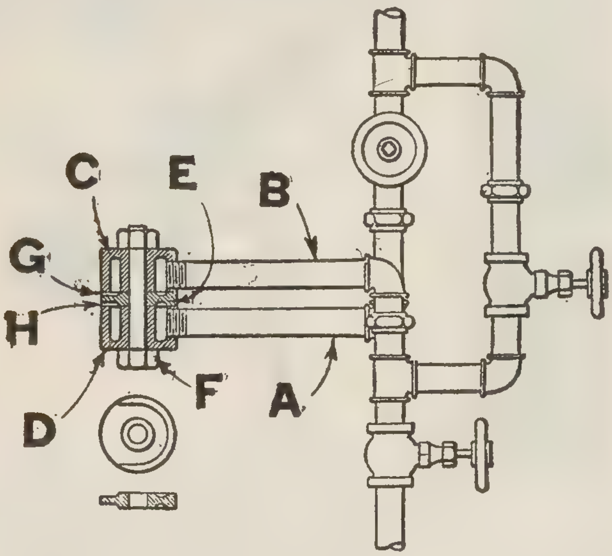
Capacity of Burners.—As rated by manufacturers, burners may be obtained in sizes ranging from one, to over four hundred horse power. The question of capacity of individual burners is



FIGS. 8,904 and 8,905.—***Vaporizing*** or ***gas*** type burner and method of installing in small marine boiler. It is designed for naphtha, benzine, gasoline or other light hydrocarbons or ordinary headlight oil, of 150° test. ***In operation,*** the oil is supplied through a pipe to the vaporizing retort indicated by the letter A. In its passage through the fire box and this retort it is converted into a vapor or gas, which burns without odor, soot or residuum. From the top of the retort A, the gas is conveyed through an elbow pipe C, (as shown by arrows) to the mouth of the burner, where it escapes through a small opening D, (made adjustable) and is ignited. The flame striking centrally upon the bottom of the retort A, is spread in every direction, thus serving the double purpose of generating the gas in the retort and distributing the heat equally to every portion of the boiler. Working into this small opening D, is a shut off plunger E, which, raised or lowered, controls the flow of the gas. This plunger is connected by means of a rod E^1, counter-balanced rock shaft E^2, bell crank lever E^3, connecting rod E^5, to bell crank lever H, and to a hollow spring on the outside of the furnace. The weight of these rods is counter-balanced by the rod and ball E^4. The hollow spring is supplied with steam at boiler pressure through a small pipe at opening K. The saucer F, is for oil or alcohol used in raising the proper heat under retort at starting, and until sufficient gas is manufactured for its own reproduction; a matter of three or four minutes. The burner is furnished with removable plugs BB^1, and B^2, to facilitate cleaning. Rock shaft E^2, is furnished with stuffing box G, to prevent leakage. It will readily be seen that the straightening of the spring caused by an increase of pressure in the generator, operates directly on the plunger by means of the adjusting screw I, bell crank lever H, and intermediate connections; thus perfectly establishing the relation between steam pressure and fire. Should the steam pressure rise, the plunger would close off the flow of gas correspondingly, and vice-versa, thereby regulating the heat of the fire. The plunger cannot, however, shut off the flow of gas entirely; a small orifice is always left, enough to keep the burner and generator hot; and in this way, the trouble and annoyance from having to relight the fire after every stop is avoided.

largely one of the proper relation between the number of burners used and the furnace volume.

In some recent tests with a Babcock & Wilcox boiler of 640 rated horse power, equipped with three burners, approximately 1,350 horse power was developed with an available draft of the .55 inches at the damper or 450 horse power per burner. Four burners were also tried in the same furnace but the total steam generated did not exceed 1,350 horse power or in this instance 338 horse power per burner.



FIGS. 8,906 to 8,908.—Slot oil burner with renewable disc. The steam pipe A, and oil pipe B, are made of such length as to bring the tip of the burner to the proper point in the furnace. The burner consists of two cup shaped castings C and D, separated by a narrow disc E. The three pieces are of the same diameter and are held together firmly by the central bolt F. As shown in the separate views, the disc E, has its rim cut away on both sides for about one-third of its circumference. Thus, when it is bolted between the castings C and D, two slots G and H, are formed, extending about one-third of the way around the burner. The oil flows through the upper casting C, and drools over the edge of the disc E, from the slot G. The steam flows through the lower casting D, and escapes through the slot H, meeting the oil and spraying it so as to produce a wide fan shaped flame. The greater part of the wear due to erosion comes on the disc E, which can be renewed when badly worn. The arrangement of the regulating valves for oil and steam and of the by pass for cleaning is similar to that already described.

From the nature of mechanical atomizing burners, individual burners have not as large a capacity as the steam atomizing class. In some tests on a Babcock & Wilcox marine boiler, equipped with mechanical atomizing burners, the maximum horse power developed per burner was approximately 105. Here again the burner capacity is largely one of proper relation between furnace volume and number of burners.

Furnace Design.—The furnace of an oil burning system is, without exception, the most important part of the entire installation, as far as the efficiency of operation is concerned. Of course, for convenience and to insure continuity of operation, it is essential that particular attention be given the design and installation of the balance of the system, that is, the

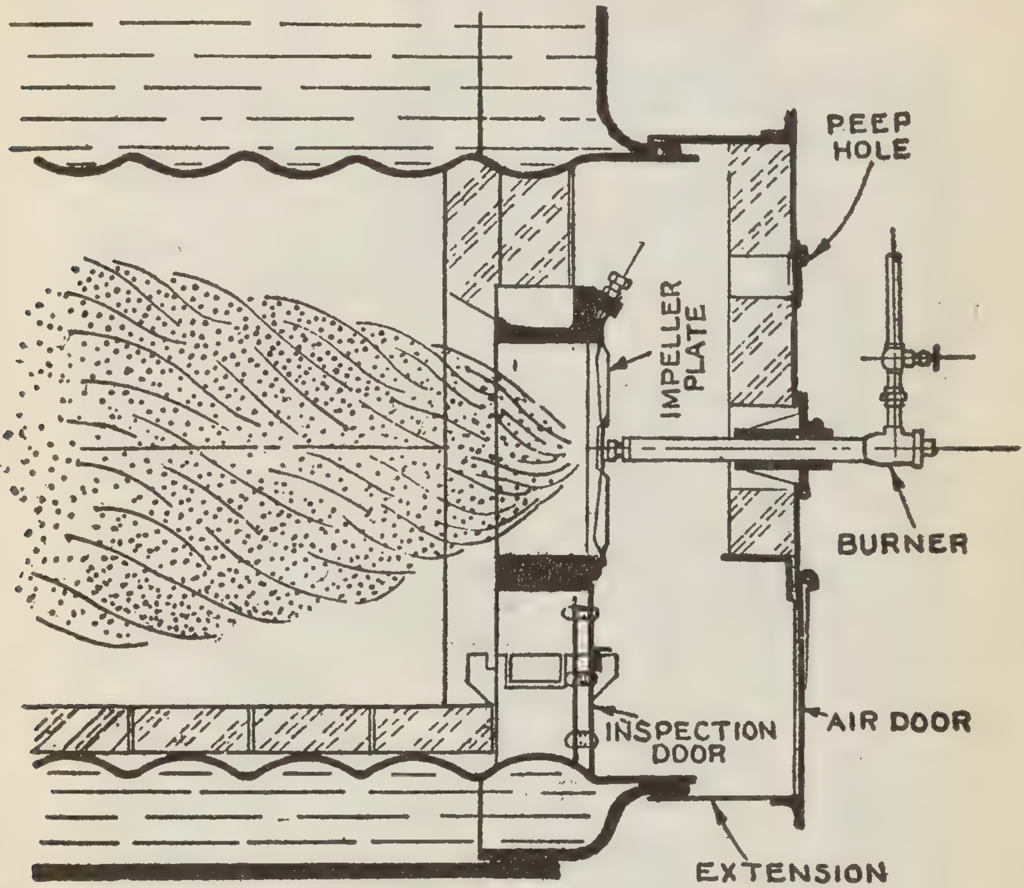
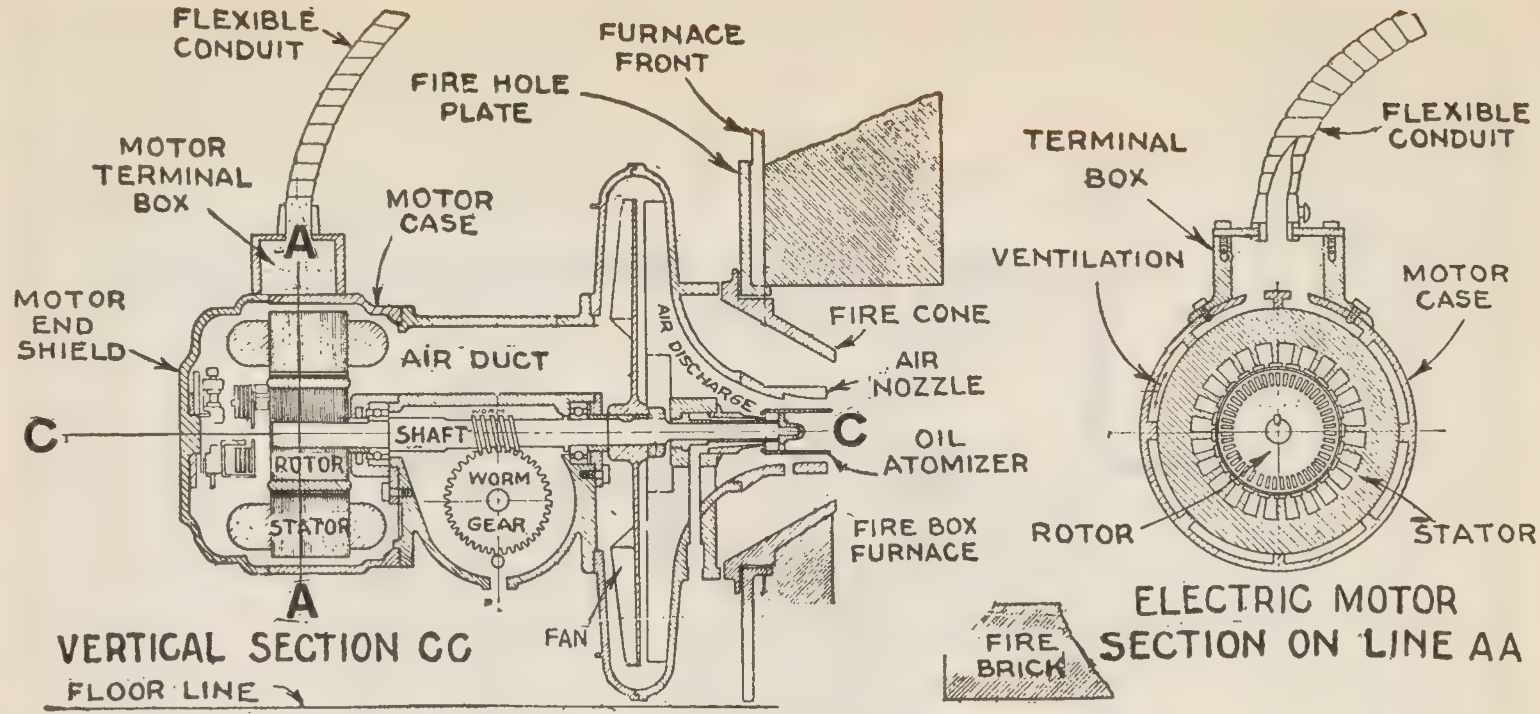


FIG. 8,909. Peabody mechanical burner as applied to a Scotch marine boiler.

storage facilities, the piping layout, the size, capacity, and flexibility of the pumping and heating installation, and the selection of the burner or atomizer used—but, even if this be done and the best possible installation has been secured, the oil burning system is doomed to almost certain failure if the design of furnace used receive insufficient attention or if the



FIGS. 8,910 to 8,912.—Sectional views of Johnston rotary burner and motor.

matter of furnace design be left to one not thoroughly familiar with oil burning requirements.

The subject of proper furnace design is a difficult one at best. Until the last few years, the knowledge of oil burning requirements has been scant, and installations were practically universally made by rule of thumb, all furnaces having been patterned, as nearly as possible, after some existing design which had been known to give satisfaction. Under such conditions, it was inevitable that numerous cases arose where installations of furnaces were made, the characteristics of which made them absolutely unsuited to the work which they were supposed to perform, resulting in installations operating at low efficiencies, and not infrequently with serious damage to both furnaces and boilers.

There are in service at this time, literally dozens of different types of boilers, all of which have different characteristics which require consideration when a boiler furnace is to be designed. Added to this the facts, that rarely are two settings encountered which are identical, that draft conditions in no two boiler rooms are alike, that load conditions and fluctuations are never the same, even in two otherwise exactly similar boiler room installations, that the characteristics of the feed water and its scale forming properties have a direct bearing on the success of an instalation, and it will be readily appreciated why improper furnace design may lead to difficulty.

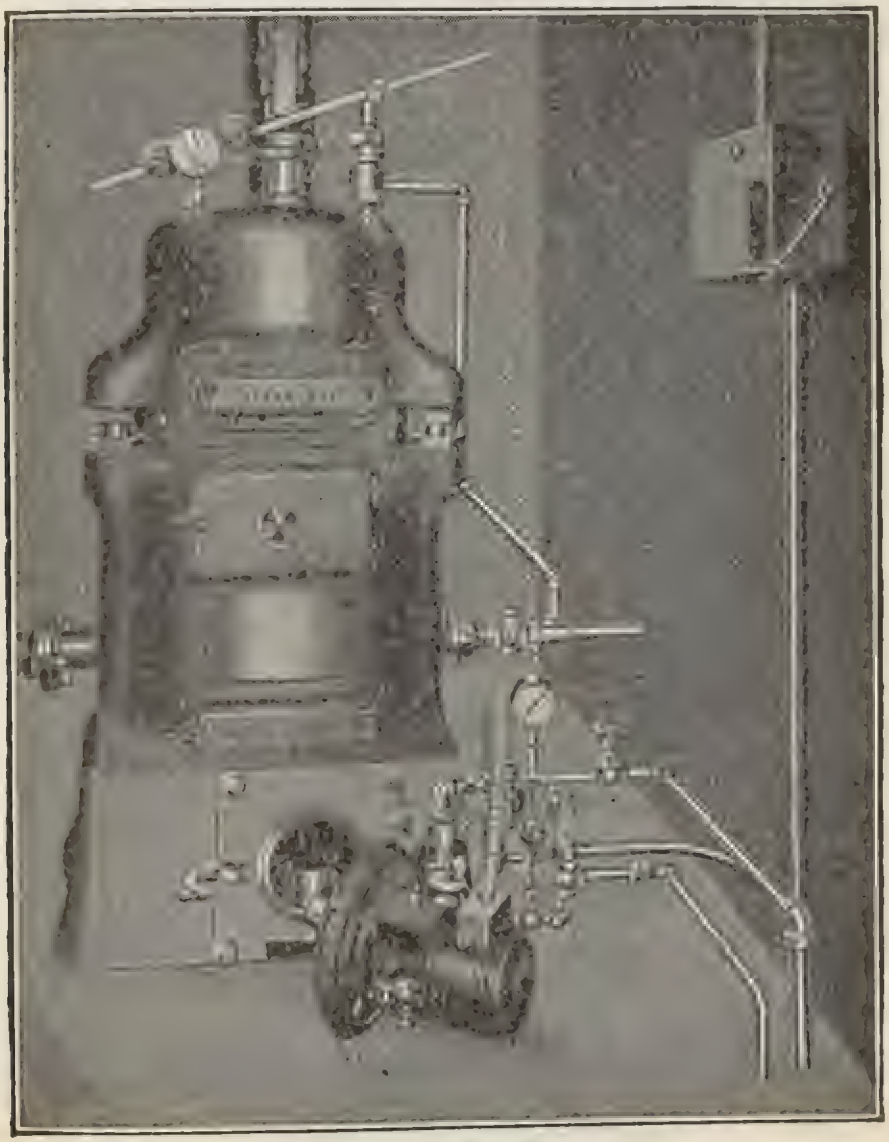


FIG. 8,913.—Johnson rotary burner with *d.c.* motor operating a cast iron steam heating boiler with automatic control.

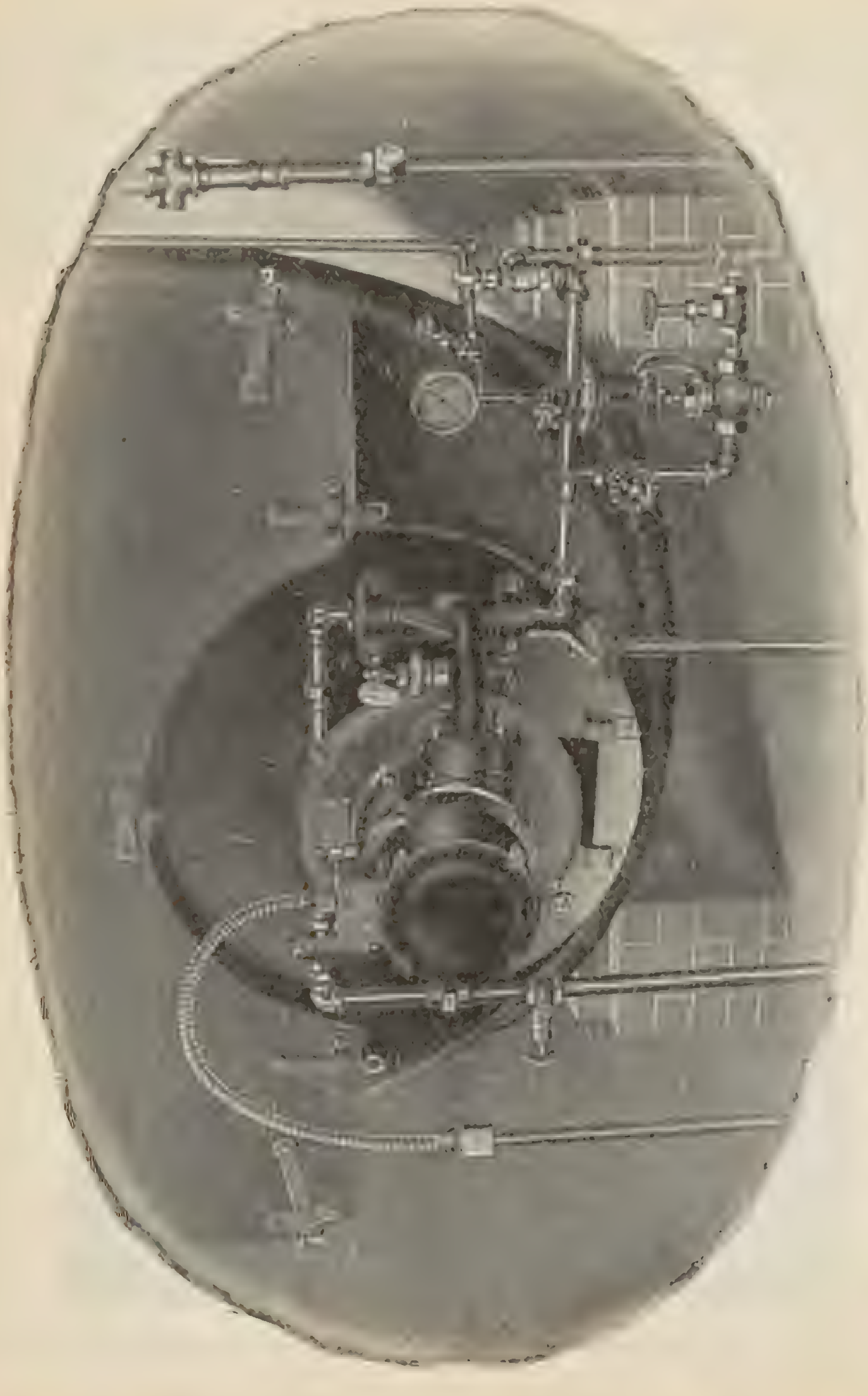


Fig. 8,914.—Johnson (No. 4½) rotary burner serving a 100 horse power Scotch marine type boiler with automatic control.

The problem of satisfactorily burning oil in a boiler furnace is entirely different in its essentials from that of burning any other fuel. In the first place, the body of the fuel is moving, and while it is in motion, the air for combustion must be supplied in such a way that combustion is completed in the furnace, and at the same time, for efficiency, the air for combustion must be limited in quantity to an amount only slightly in excess of that theoretically required for the complete combustion of fuel. This in itself makes it necessary that the subject of burning oil be treated very differently from the problem of burning coal on a fixed or slowly moving grate. Then, too, the matter of refactories, heating surface, and furnace temperatures, all

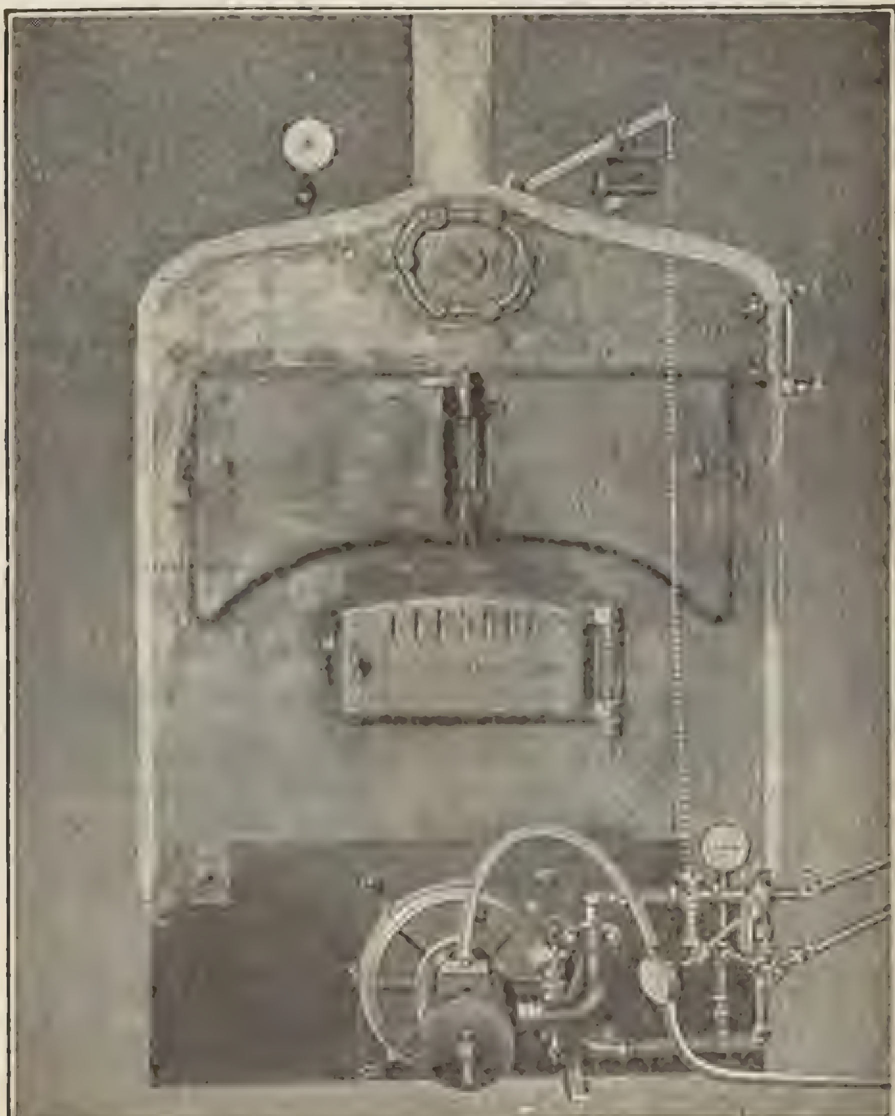
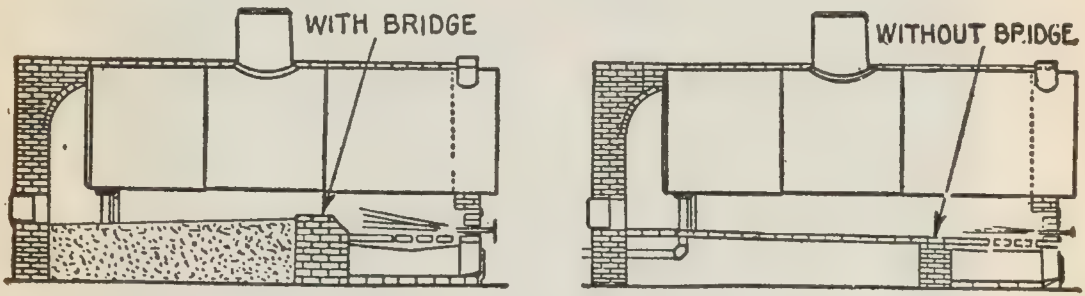


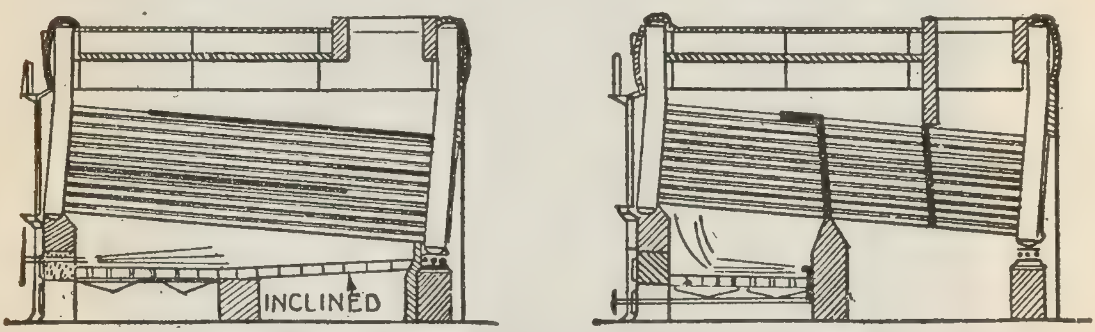
FIG. 8,915.—Johnson rotary burner operating a small hot water heater with thermostat control.

require consideration. The various complications which develop and chances that exist of going wrong make the matter of oil burning furnace design truly one for an expert, qualified by experience and training to appreciate the scope of the factors involved and to design to meet the conditions.

The furnace should be of such shape, volume and arrangement that the combustion of the gases is completed in the body and that the gases are suitably retarded so that all possible heat is absorbed by the heating surface.



Figs. 8,916 and 8,917.—Improper and proper furnace design for horizontal tubular boiler. In fig. 8,916 the flame striking the inclined target is directed upward where it can impinge on the metal of the shell and injure same. In fig. 8,917, the flame has a free space the entire length of the boiler.

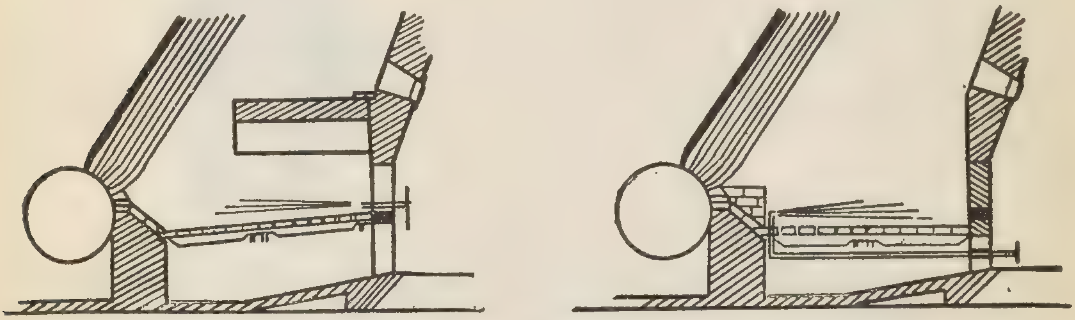


Figs. 8,918 and 8,919.—Arrangement of oil furnace for water tube boilers with horizontal and vertical baffles.

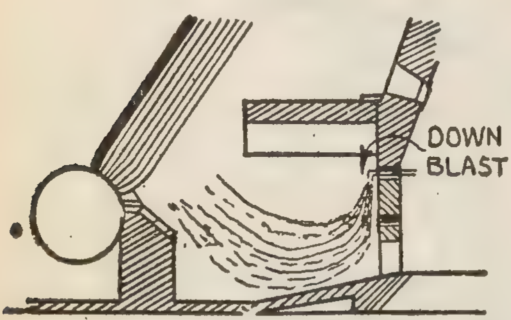
The burners should be so placed that the products of combustion as they leave the oil, burning first, do not impinge on the cold tubes and metal of the boiler.

It is important to keep the side and bottom burners far enough from the side and bottom walls to prevent the formation of heavy masses of carbon by the oil spray, as these masses will eventually produce poorer combustion.

The flames from mechanical atomizing burners have a less velocity of projection than those from steam atomizing burners and if introduced into the higher end of the furnace, should not lead to tube difficulties provided they are properly located and operated. This class of burner also will give the most satisfactory results if introduced so that the flames travel in the direction of increase in furnace volume.



Figs. 8,920 and 8,921.—Faulty and well designed furnace for Sterling boilers. In fig. 8,920 the flame is liable to impinge on the tubes.



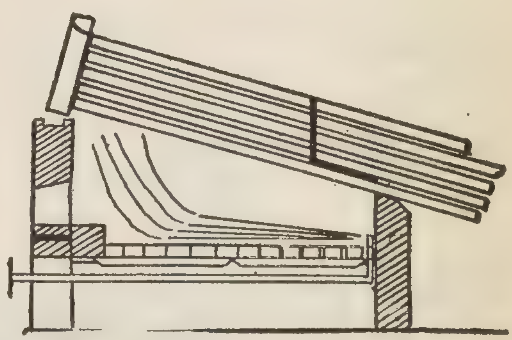


Fig. 8,.922—Down draught arrangement under Sterling boiler.

Fig. 8,923.—Furnace for Babcock and Wilcox boiler.

The practice of using brick arches, checker work, target walls, etc., is unnecessary and is frequently the cause of the burning out of tubes or bagging the boiler. With such arrangement the cost of furnace repairs becomes very high and they are likewise often the cause of interruptions of service.

Ques. What is the objection to target walls?

Ans. They not only limit capacity but cause a localization of heat.

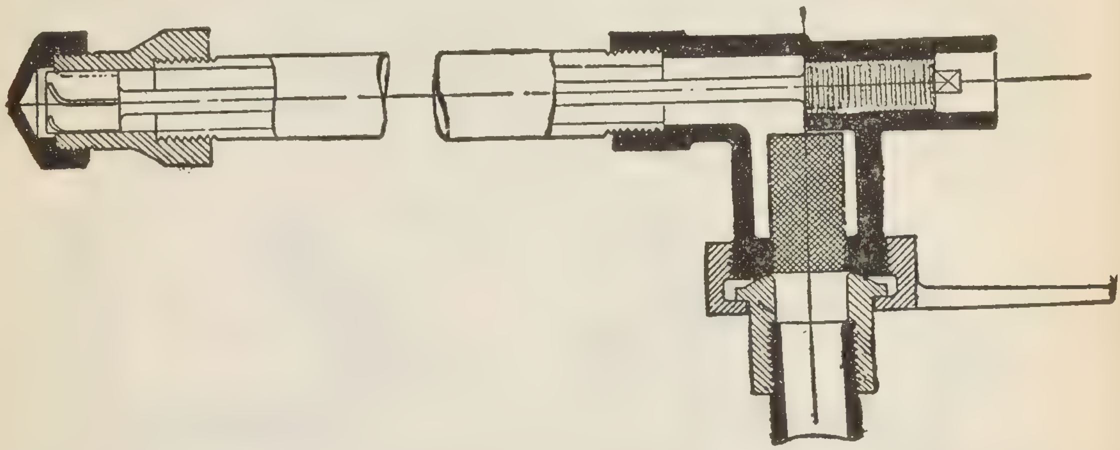
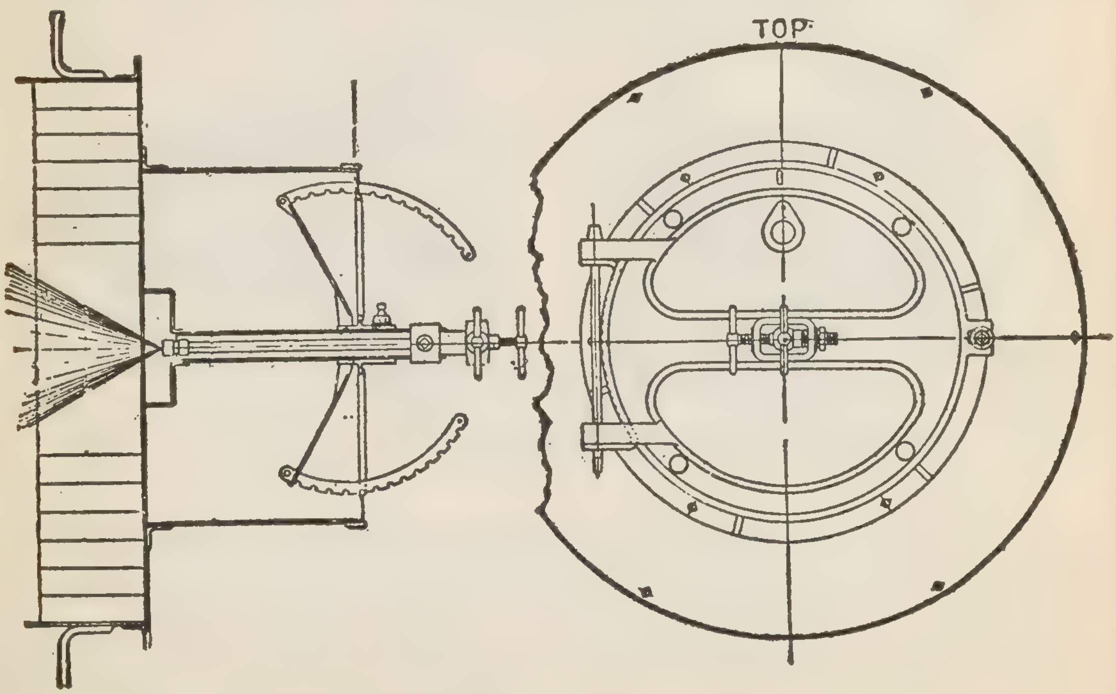


FIG. 8,924.—*Moore & Scott* burner. The oil is delivered to the chamber communicating with the discharge orifice, through oil passages cut in the sides and on the end of a plug which is adjustable in the direction of the axis by means of a spindle passing completely through the burner; a special strainer is used and the union for connecting the oil piping is fitted with a special means for detaching quickly.



FIGS. 8,925 and 8,925.—*Moore & Scott* air control as arranged for use in the furnace of a Scotch boiler.

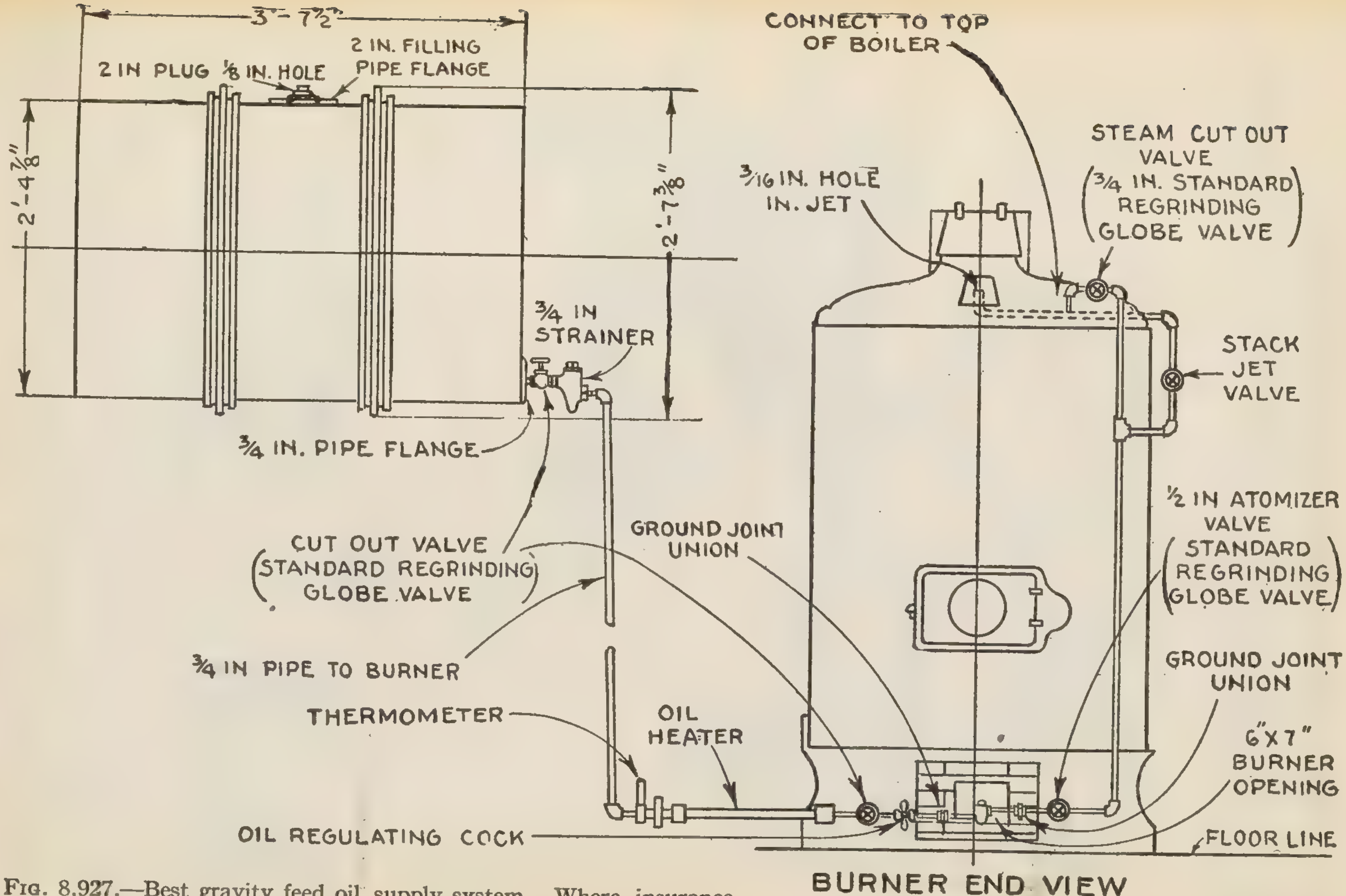
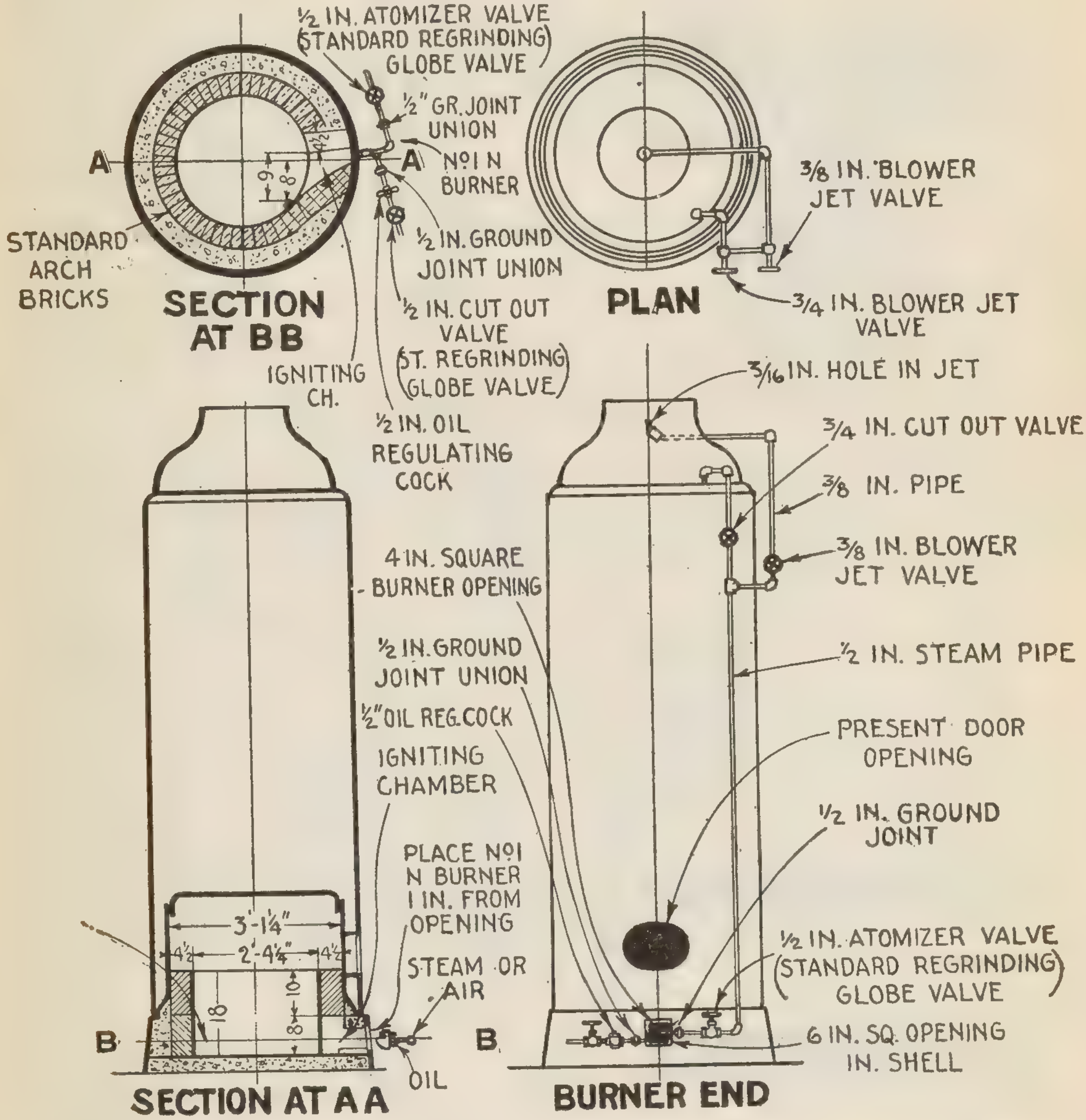


Fig. 8,927.—Best gravity feed oil supply system. Where insurance regulations permit the location of oil storage tanks above ground and where a light grade of oil (not heavier than 20° Baumé) is used, a gravity supply system, similar to the one shown above, can be installed. This system should be used only when both the conditions mentioned above apply. In most instances, however, a pumping system is more advantageous.

Ques. How should the furnace be designed?

Ans. It must be so arranged that the flame will not impinge on either the boiler or brick work.



FIGS. 8,928 to 8,931.—Installation of Best burner on vertical boiler showing furnace design for tangential flame equipment which prevents the impingement of flame and heat upon the elements of the boiler.

The disastrous effects of the blow pipe action of the oil flame on the metal of boilers is well known.

To secure the best results, the furnace must be so arranged that 1, all air must pass through the flame; 2, the atomized oil must be completely burned while suspended in the air; 3, a large surface of brick work must be exposed near the flame; and 4, the flame ought to be distributed over a large area.

Ques. What causes the brick work to "melt out?"

Ans. This is due to the intense heat, and sometimes to certain agents present in some oils which cause a fluxing action.

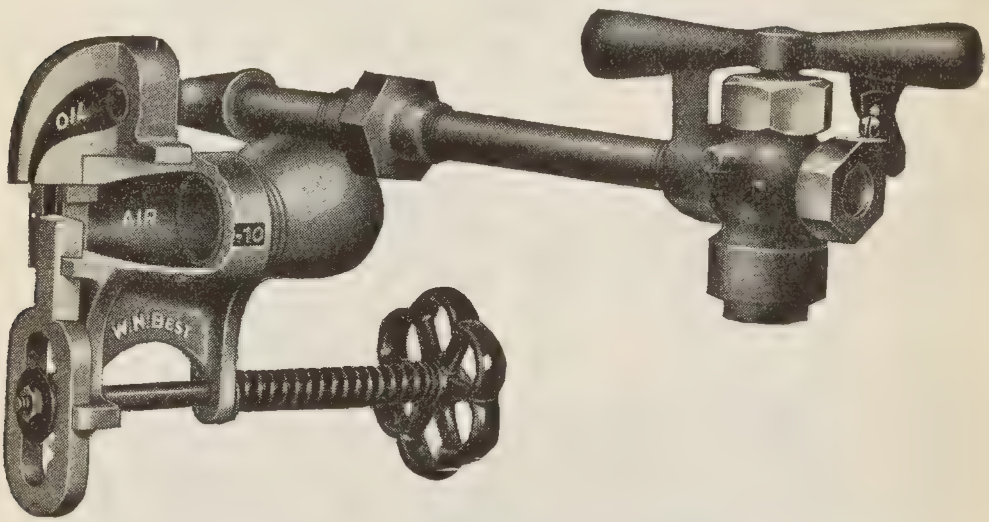
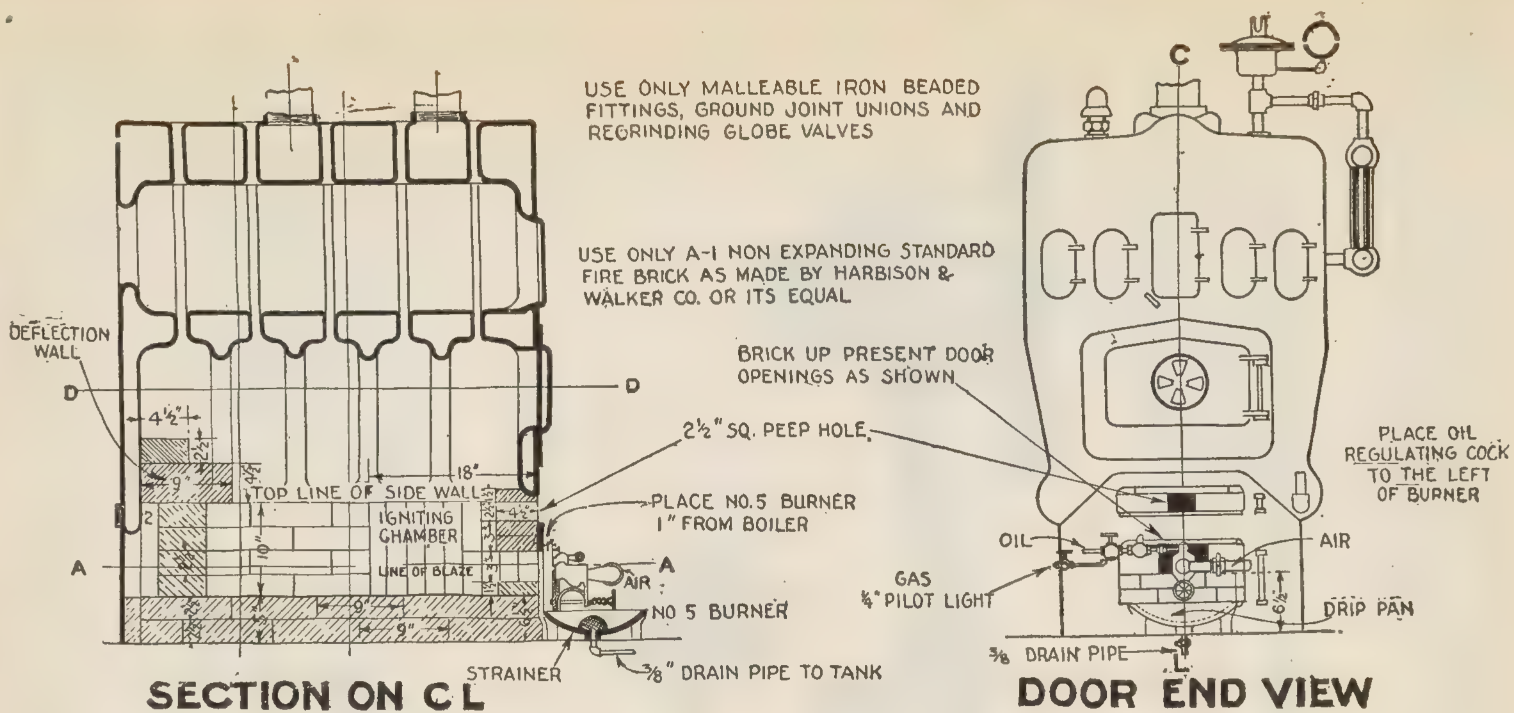


FIG. 8,932.—Best low pressure and volume air burner designed for use on low pressure steam and hot water boilers.

Efficiency Maintained in Oil Burning Furnaces.—When an oil burning equipment has been properly completed, there still remains the important problem of securing efficient operation continuously. This problem in itself is of major importance, and is one which is too often neglected, it seeming to be a fairly general idea in very many instances that provided the installation is well made and the furnace designs are correct, efficient operation will be secured with little or no attention. A good design, however, in the case of an oil burning installation,



FIGS. 8,933 and 8,934.—Typical installation of Best low pressure burner to low pressure steam heating boiler.

cannot be effectively utilized unless attention be given to proper operation; in this respect it is safe to say that the success of an oil burning installation is entirely in the hands of the operating force, and that the most careful and accurate engineering in connection with the laying out and installing the apparatus can be rendered worthless by carelessness on the part of men who are to run the system after it is once in place. The work of the oil burning engineer, or designer of oil burners in connection with new equipment is to provide apparatus and furnaces which are capable of being

operated efficiently and accurately, and when this is done he has fulfilled his obligation.

It therefore should be the aim of every owner of an oil burning installation to be sure that his operating force is thoroughly familiar with all parts of the apparatus, and is conversant to a practical degree with the factors which affect operating efficiency and with the causes and means of avoiding losses in oil-burning furnaces.

The most common cause of loss in efficiency when burning fuel oil is due to the presence in the combustion chambers of excess air; that is, air in a greater quantity than that required to completely consume all combustible

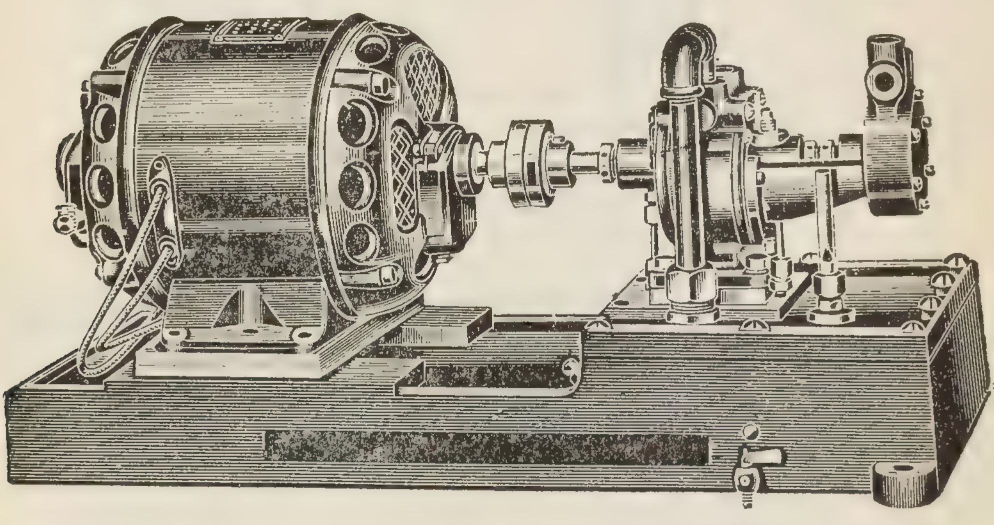


FIG. 8,935.—Best combination oil and air pump for low pressure oil supply systems.

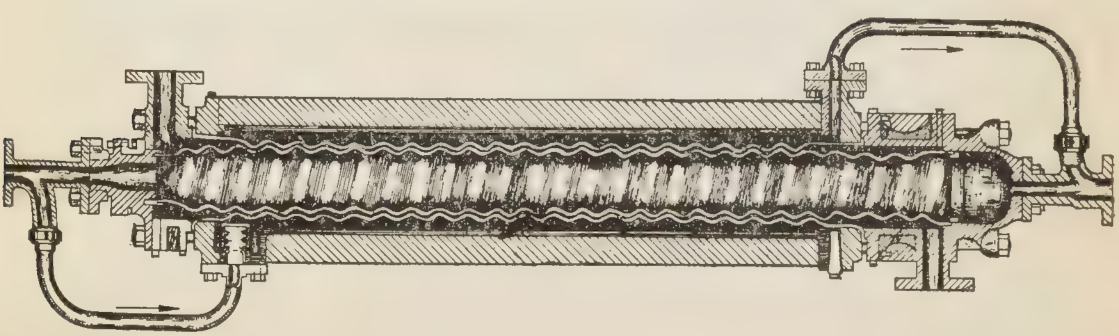


FIG. 8,936.—*Schutte and Koerting* film oil heater. In this heater (invented by Lovekin) oil is forced in a thin film between two steam heated surfaces of such shape that the oil is continually being mixed or stirred in passing through the heater.

matter in the fuel. The reason that there is always a loss in efficiency when excess air is present in the furnace is easily understood.

Air for combustion is ordinarily taken into the furnace at room temperature, usually at something in the vicinity of 90° F. The waste gases usually leave the boiler at a temperature somewhat higher than 400° F., and oftentimes as high as 600° F.

These gases at this temperature always represent loss of heat, and where

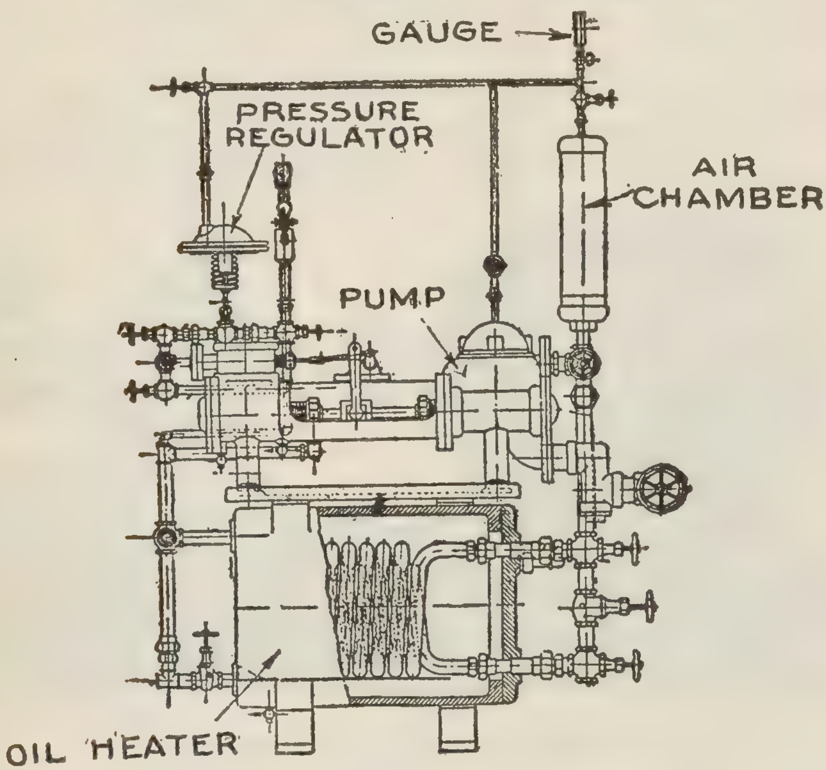


FIG. 8,937.—Lockett automatic fuel outfit. ***The heating*** is done by means of a brass coil through which the discharge from the pumps is led. The exhaust from the pumps being used to heat the oil. A live steam connection is also provided so that the oil may be heated to any desired temperature. To provide against danger in case the live steam connection be allowed to remain open when the pumps are not running, a safety valve is provided on the steam chamber. A closed oil relief valve is provided to prevent excessive oil pressure. The governor, air chamber and pump discharge chamber are provided with purge pipes to prevent any possible gas accumulation.

no excess air is present, this loss is not preventable. If excess air is being carried through the boiler, however, it will be seen that this surplus air is being heated from the room temperature to the temperature of the outlet gases, and since it serves no useful purpose in the furnace, the amount of heat required to raise the temperature of this air from the room temperature

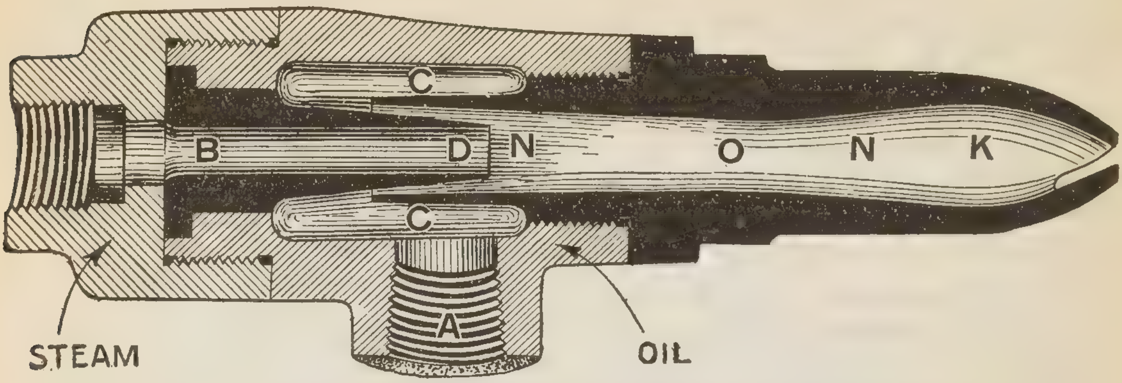


FIG. 8,938.—National low pressure burner. ***In operation,*** oil under low pressure enters the burner at A, and passes into a chamber C, which entirely surrounds the steam nozzle BD. After the first few minutes cf operation the entire burner is at steam temperature, about 300° F. or higher, and the oil while in the chamber C, is raised to about that temperature. The steam nozzle BD, extends into and discharges the steam into a forward nozzle NON, The oil passes from chamber C in an annular film into the same nozzle NON. This nozzle NON forms a venturi tube with its throat at O. The relation of the two nozzles BD and NON is so calculated that the angle of expansion of the steam leaving nozzle BD causes the steam to cut its way through and mix with the oil at O. The oil and steam so mixed then pass to the front chamber K, where they are churned into an emulsion, while the fan shaped orifice through which the oil is fed from the chamber K, into the furnace, is designed to sufficiently retard the discharge of the mixture of oil and steam during the churning process. The mixture lights readily and burns with a brilliant, fan shaped, gaseous flame.

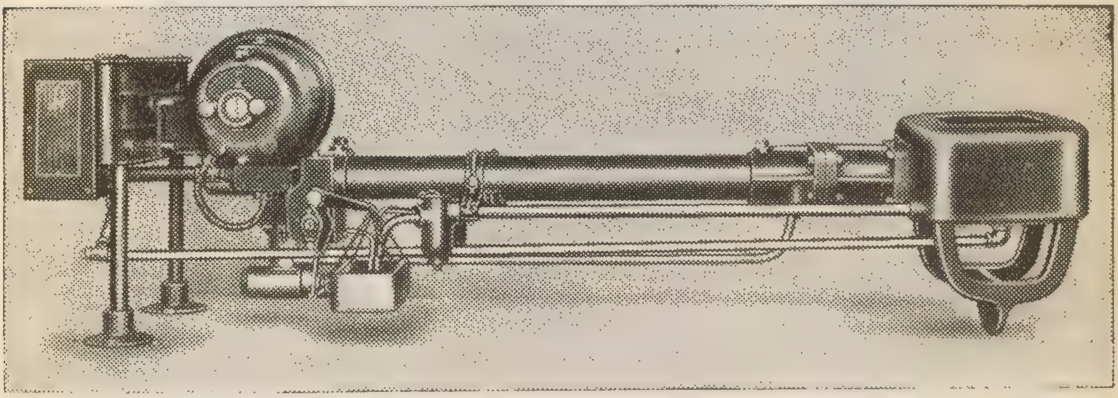


FIG. 8,939.—Nokol burner. ***In operation,*** the motor is started by a thermostat when the temperature in the room falls below the desired point. The motor operates the blower, which furnishes a forced draft of air through the atomizer located at the combustion chamber. The suction of the air draws the oil from a float chamber and feeds the finely atomized spray of fuel, mixed with the correct proportion of air, into the combustion chamber. This sprayed oil is ignited by means of the pilot light which burns continuously with a very small flame when the blower is not in operation, and which is momentarily turned higher as the blower is started, immediately returning to a small flame. The fire in the combustion chamber continues to burn until the temperature of the house rises to the required point, when the thermostat automatically stops the blower and cuts off the feed of oil to the combustion chamber. The apparatus does not start again until the temperature in the house falls below the desired point.

to the temperature of the flue gases is wasted and may be classed as a preventable loss. This air also has the effect of lowering the furnace temperature.

The presence of excess air in the flue gases may always be detected by making an analysis of the flue gases for carbon dioxide, oxygen and carbon monoxide; this may be done with the ordinary Orsat gas analyzing apparatus, with which nearly all operating engineers are familiar.

The percentage of CO_2 which can be obtained with theoretically perfect combustion varies slightly with different oil fuels, and is dependent upon the chemical makeup of the fuel; that is, the percentage of carbon, sulphur, hydrogen and other combustible matter in the fuel. Generally speaking,

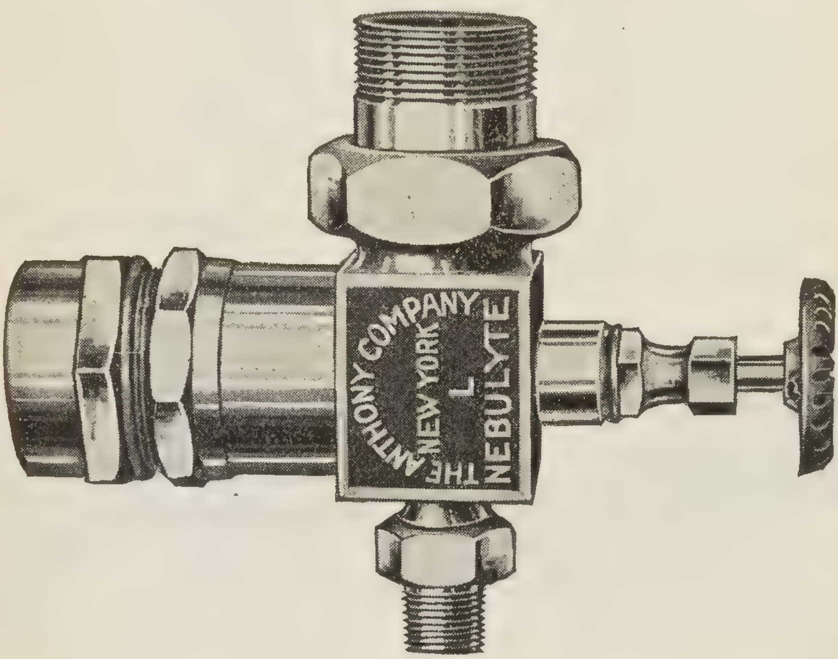


FIG. 8,940.—Anthony *high pressure* burner. Operates with air or steam. When steam is used, it is merely to inspirate sufficient air to support primary combustion. Burns any grade of fuel oil.

however, 15.8% CO_2 is the theoretical maximum percentage of carbon dioxide which can be obtained from most fuel oils, and this percentage represents perfect combustion, with no oxygen and no carbon monoxide being present in the flue gases.

In practice, however, it is of course impossible to obtain perfect combustion with no excess air, although the condition may be closely approximated, and under ideal conditions almost reached. With good operation, it is not at all unusual for an analysis of the flue gases to show 14% CO_2, and where

such results are obtained, it may be considered certain that satisfactory economy is being secured.

The preventable losses due to excess air in the furnace amount very often to a considerable sum, running somewhat better than 1% with 14% CO_2 to as high as 7% CO_2. These losses may exceed 60% of the total fuel burned when the CO_2 runs as low as 2%. It will therefore be seen that it is important that the operators realize the effect on efficiency of carrying more air into the furnaces than is required for complete combustion of the fuel, and that they be provided with some means of determining the carbon dioxide content of the flue gases, and sufficiently easy methods of controlling the air for combustion to secure accurate regulation.

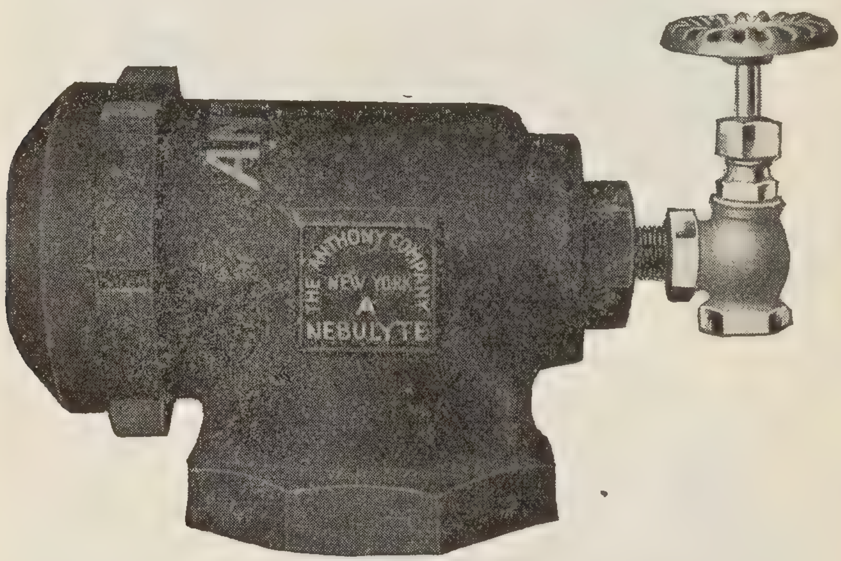


FIG. 8,941.—Anthony *low pressure* burner. Air at only 2 ozs. to 12 ozs. is supplied for combustion support, and oil at 20 lbs. to 125 lbs., depending upon conditions sought. The maximum available capacity is determined by operating pressures in conjunction with forced or induced draft, but the actual maximum is often restricted for operating reasons to the particular requirements of each installation.

Furnace Walls.—In laying up brick walls and flooring of oil furnaces, provision should be made for expansion, but it is worth noting in this connection, that there is a great difference in the coefficient of expansion of fire brick. It is possible to secure highly refractory brick and tiles made of material which expands but slightly, not over 1/16 in. in 9 in.

The Babcock & Wilcox Company uses a light wash for making joints,

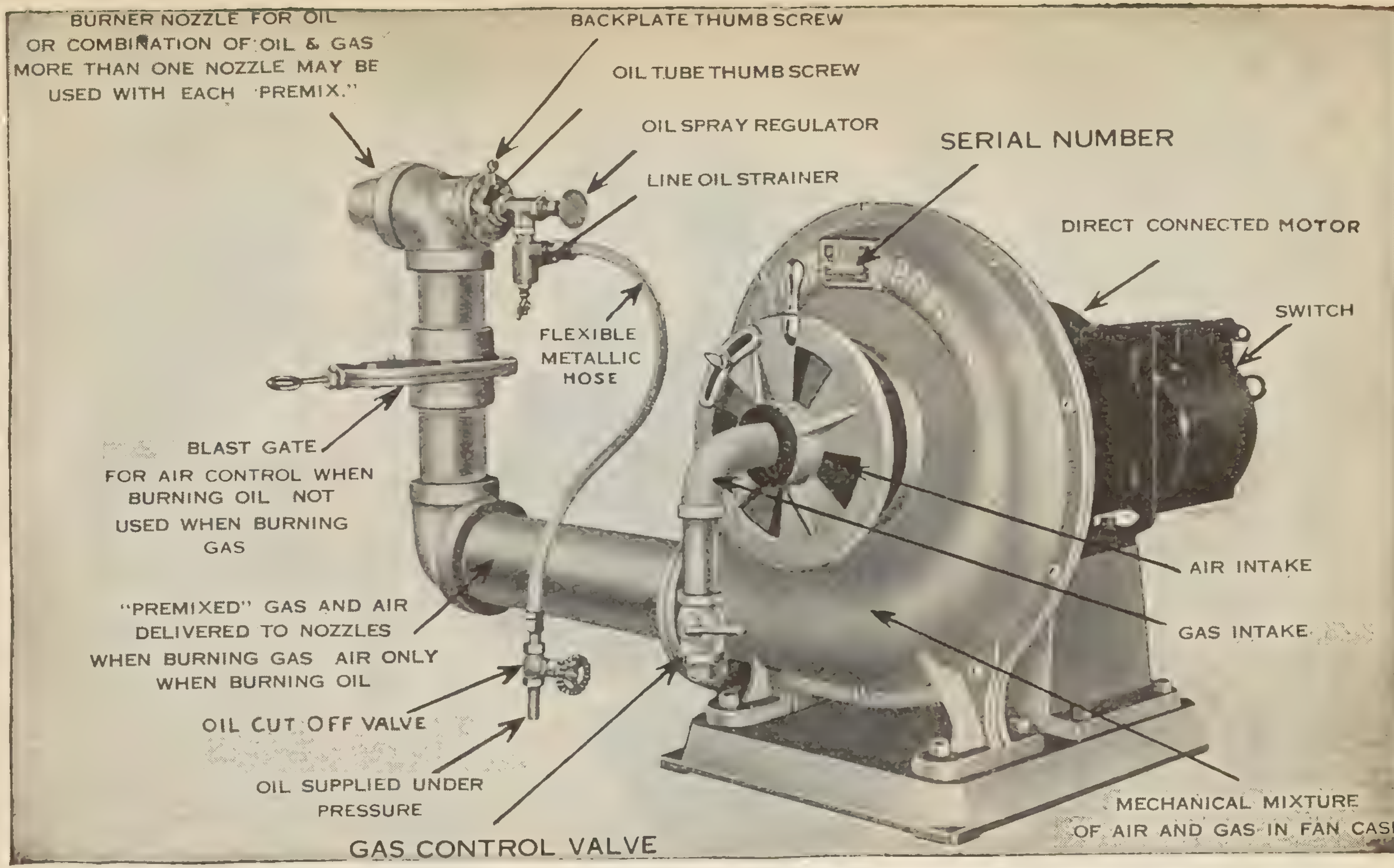


FIG. 8,942.—Maxon Premix burner unit. ***It consists of*** a direct connected motor driven low pressure blower (steam turbine drive can also be furnished on larger sizes) which supplies the air necessary for combustion to the requisite number of nozzles. Each nozzle contains a spray tip, which atomizes the oil by means of pressure on the oil supply. This pressure should not be less than 50 lbs. per sq. in. to insure proper atomization.

composed of 15 parts (by weight) of fire clay, 5 parts of carborundum sand, and 1 part silicate of soda.

The special high temperature cements on the market are a needless expense for new work but are very effective for repairs, where they find a special field of usefulness.

It is a good idea to throw a few old glass bottles into the furnace to make a glaze on the bottom surface and fill the cracks.

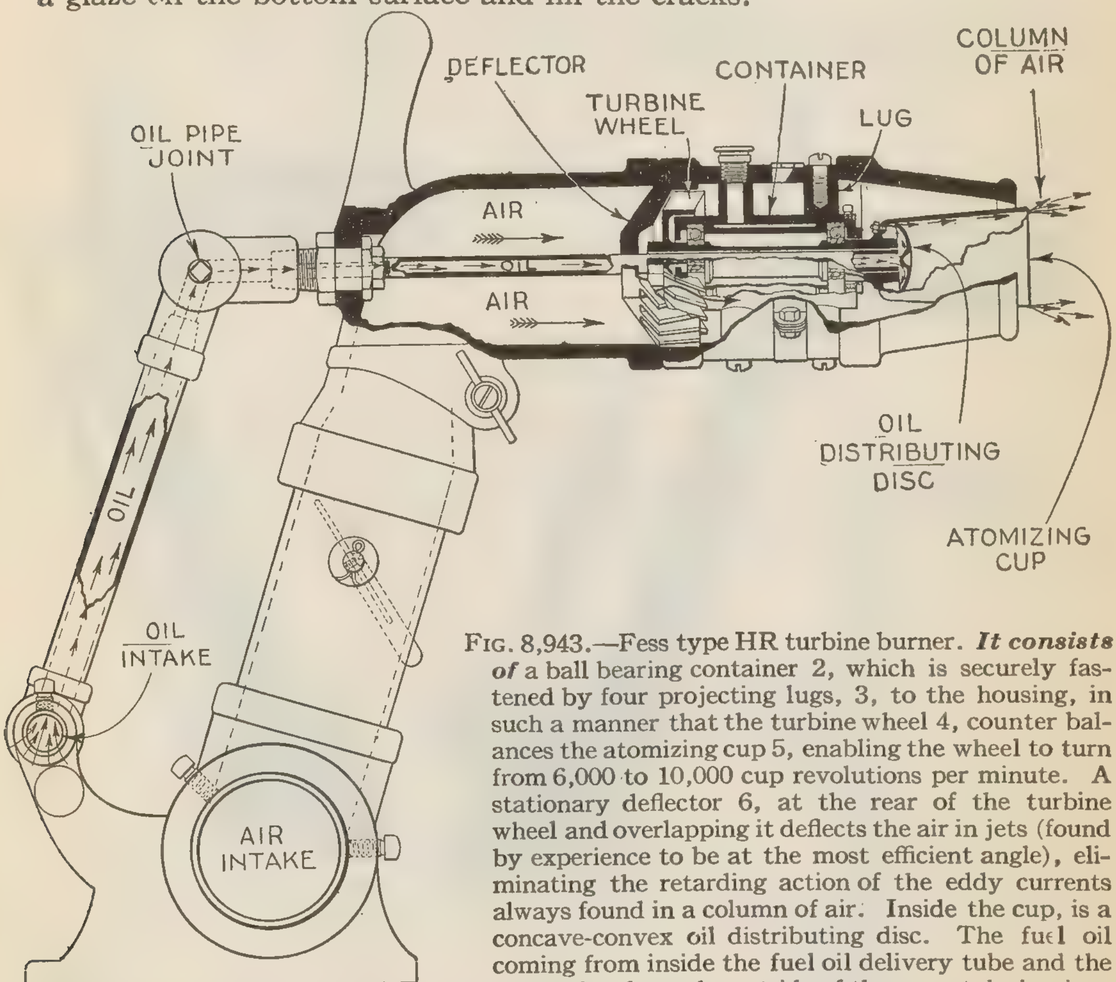


FIG. 8,943.—Fess type HR turbine burner. ***It consists of*** a ball bearing container 2, which is securely fastened by four projecting lugs, 3, to the housing, in such a manner that the turbine wheel 4, counter balances the atomizing cup 5, enabling the wheel to turn from 6,000 to 10,000 cup revolutions per minute. A stationary deflector 6, at the rear of the turbine wheel and overlapping it deflects the air in jets (found by experience to be at the most efficient angle), eliminating the retarding action of the eddy currents always found in a column of air. Inside the cup, is a concave-convex oil distributing disc. The fuel oil coming from inside the fuel oil delivery tube and the air coming from the outside of the same tube impinge against this disc, and are partially mixed when striking the inside of the atomizing cup in a thin emulsified form. When the mixture of oil and air (which is thinly spread over the inside surface of the cup) leaves the mouth of the cup, it takes up additional oxygen from the column of air. In this highly combustible state, the oil vapor immediately flashes into gas and ignites, making a clear, intense flame.

FIG. 8,942.—*Text continued.*

this mixture is carried into the furnace where combustion takes place. Air supply is regulated at the Premix by means of a disc shutter valve or by blast gates at each individual nozzle, if more than one nozzle is used.

Points Relating to Oil Burning Plants.—In fitting up a plant for oil burning, the following points are important:

1. Provide ample means for delivering clean hot oil to the burners.
2. Select a type of burner that will maintain a flame in a cold furnace.

In designing a furnace, practice has shown:

FIGS. 8,944 and 8,.945—Fess turbine burner. Fig. 8,944 burner in firing position; fig. 8,945, burner out of firing position.

1. That practically all air must pass through the flame.

2. That the flame must *not* be allowed to impinge directly on either boiler sheets, tubes or brick work.

3. That the flame produces better results when worked near hot brick.

4. That the flame should be distributed over as large an area as possible to prevent localization of heat.

5. That every precaution must be taken to guard against excess air.

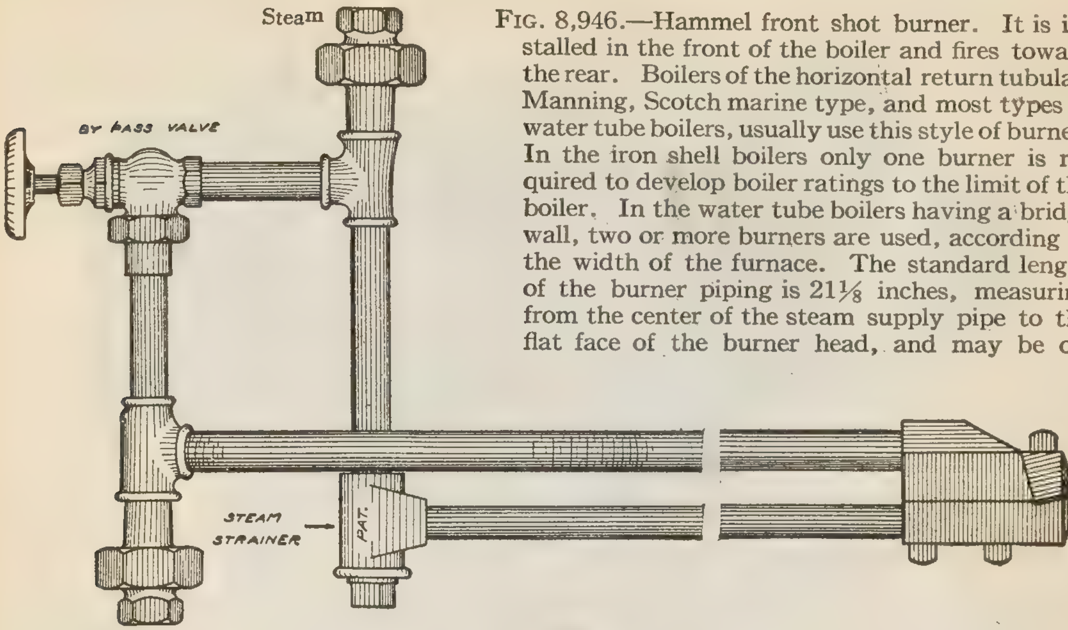


FIG. 8,946.—Hammel front shot burner. It is installed in the front of the boiler and fires toward the rear. Boilers of the horizontal return tubular, Manning, Scotch marine type, and most types of water tube boilers, usually use this style of burner. In the iron shell boilers only one burner is required to develop boiler ratings to the limit of the boiler. In the water tube boilers having a bridge wall, two or more burners are used, according to the width of the furnace. The standard length of the burner piping is 21⅛ inches, measuring from the center of the steam supply pipe to the flat face of the burner head, and may be ordered in varying lengths to suit special requirements. Various tips from ½″ to 1⅝″ are made for various flame widths, and apply likewise to the No. 5 burner. Burners, when in place, should have the face of the burner protruding into the furnace not more than three-quarters of an inch.

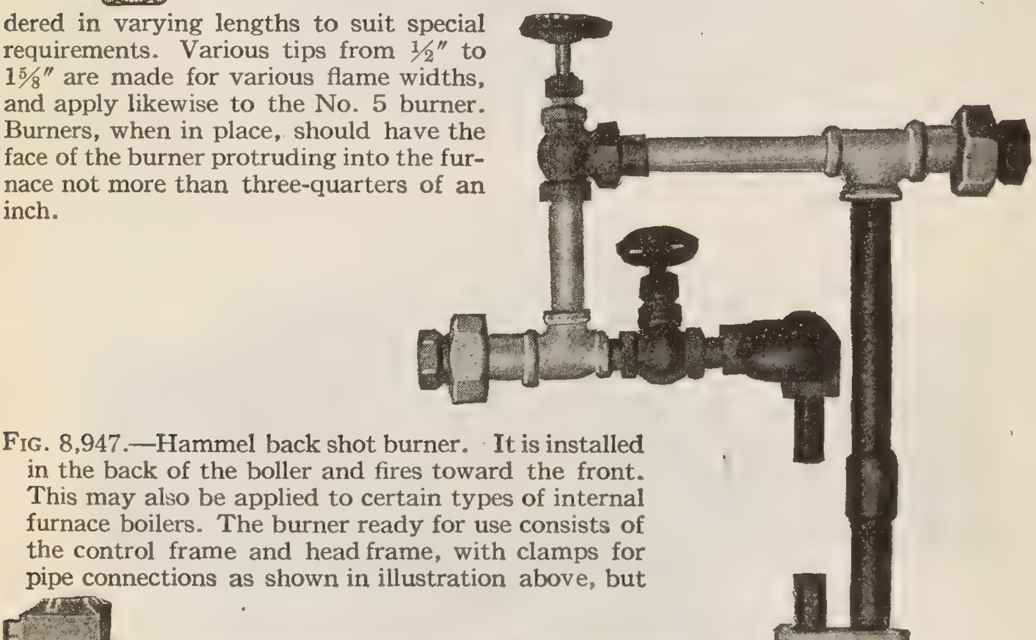


FIG. 8,947.—Hammel back shot burner. It is installed in the back of the boller and fires toward the front. This may also be applied to certain types of internal furnace boilers. The burner ready for use consists of the control frame and head frame, with clamps for pipe connections as shown in illustration above, but shipped without the connecting pipes to save shipping space. The burner complete is usually 10 to 12 feet long, and is easily removed and replaced by a fireman when required for cleaning.

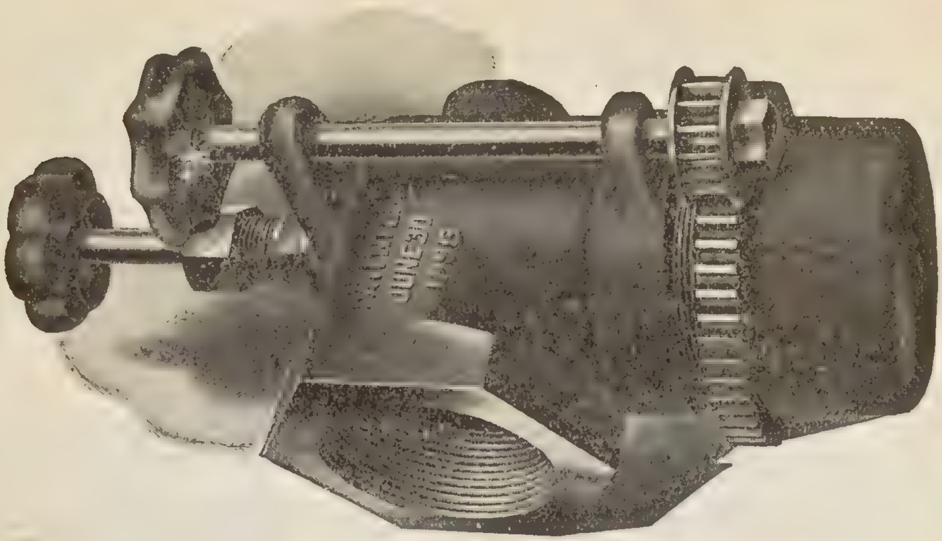


FIG. 8,948.—Gilbert and Barker low pressure *adjustable* burner. ***Air and oil*** enter from opposite sides of the burner and do not intermingle inside the burner. The oil is conveyed in a casting through the center, the air around the outside of this casting. The oil outlet, or tip, is cone shaped at the end, while the outside cap, or air tip, as it is called, is machined to an angle. By moving the air tip toward or away from the oil tip, by means of the gear arrangement provided, the amount of air passing through the burner is governed, while the form of the air jet always remains the same. By this means a wide regulation can be obtained with unvarying results at different capacities.

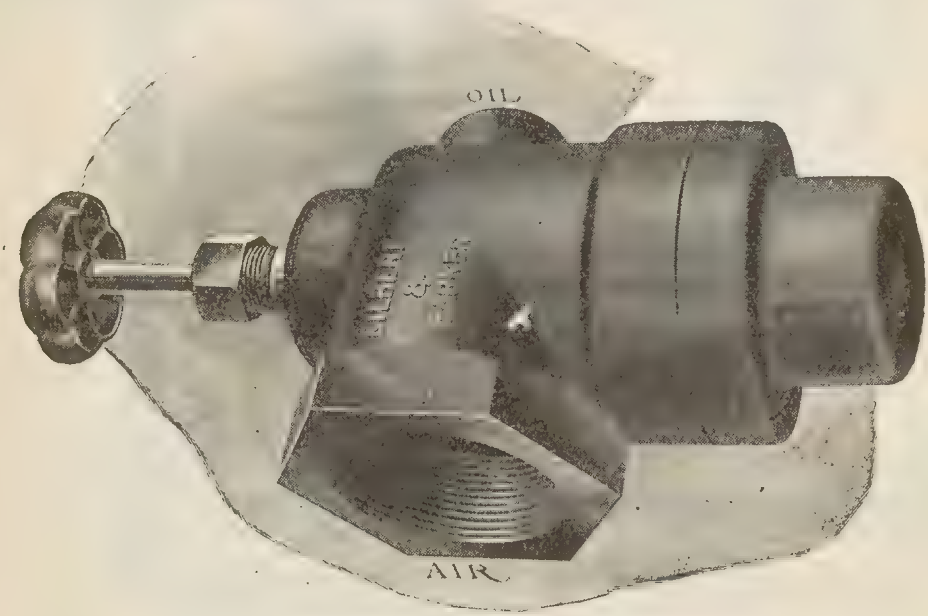


FIG. 8,949.—Gilbert and Barker fixed single jet burner designed for use where a nearly constant condition is met with. The air orifice is fixed. ***It can be operated*** on air at 8 oz. or more. Made in sizes from ½ to 3 ins.

Operation of Burners.—When burners are not in use, or when they are being started up, care must be taken to prevent the oil flowing and collecting on the floor of the furnace before it is ignited. In starting a burner, the atomized fuel may be ignited by a burning wad of oil soaked waste held before it on an iron

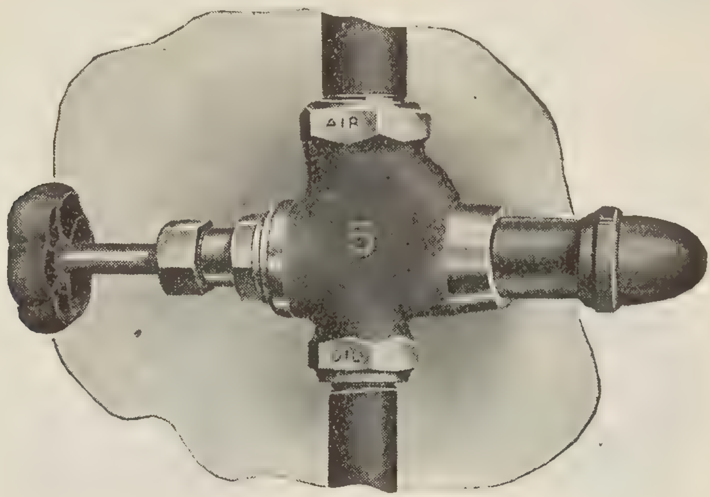


FIG. 8,950.—Gilbert and Barker high pressure burner suitable for air at 15 lbs., or more and is supplied in ½ in. and ¾ in. sizes.

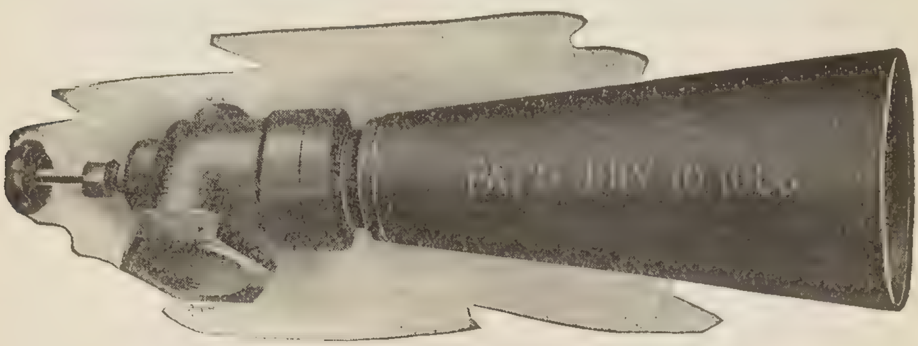


FIG. 8,951.—Gilbert and Barker megaphone, *adjustable* or *fixed* burner. Used in obtaining long soft flames, such as in japanning ovens, skin drying rotary kilns, etc.

rod. To insure quick ignition, the steam supply should be cut down. But little practice is required to become an adept at lighting an oil fire. When ignition has taken place and the furnace brought to an even heat, the steam should be cut down to

the minimum amount required for atomization. This amount can be determined from the appearance of the flame. If sufficient steam be not supplied, particles of burning oil will drop to the furnace floor, giving a scintillating appearance to the flame. The steam valves should be opened just sufficiently to overcome this scintillating action.

Air Supply.—From the nature of the fuel and the method of burning, the quantity of air for combustion may be minimized. As with other fuels, when the amount of air admitted is the min-

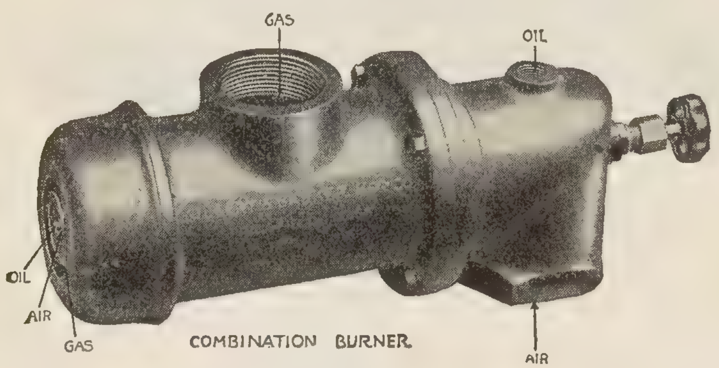


FIG. 8,952.—Gilbert and Barker combination gas and oil burner. Either gas or oil feed can be used and the two fuels can be turned on simultaneously if desired. Sometimes a little oil is added in the morning when gas pressure is low due to low temperature; it is also the means of accelerating the fire.

imum which will completely consume the oil, the results are the best. The excess or deficiency of air can be judged by the appearance of the stack or by observing the gases passing through the boiler settings.

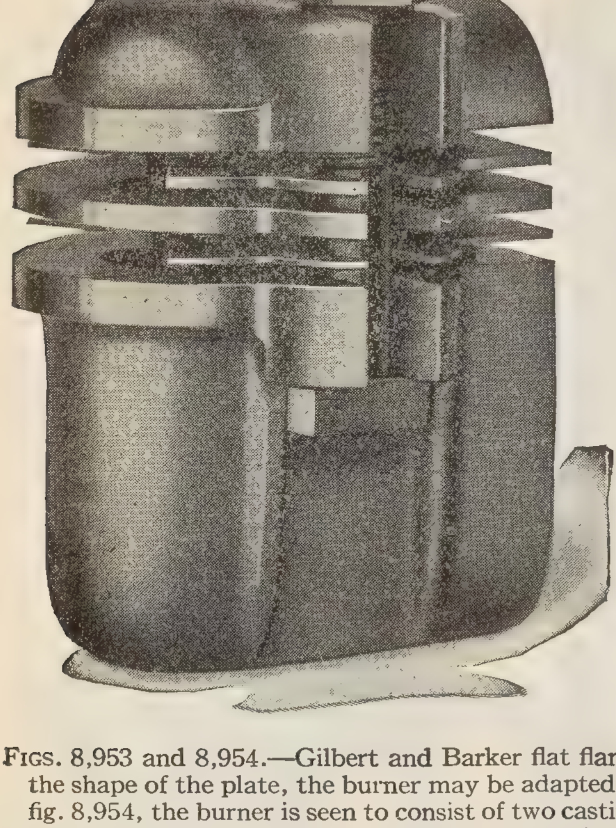
What are the air supply indications?

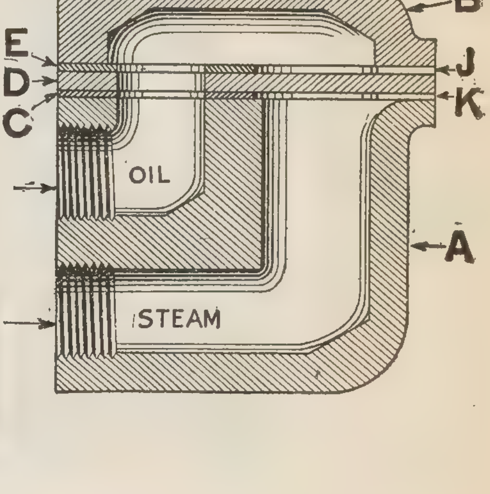
A perfectly clear stack indicates excess air, whereas smoke indicates a deficiency.

How is the proper air supply best gauged?

By running near the smoking point with a slight haze in the gases.

A slight variation in the air supply will affect the furnace conditions in an oil burning boiler more than the same variation where coal is used, and for





FIGS. 8,953 and 8,954.—Gilbert and Barker flat flame steam atomizing burner. According to the shape of the plate, the burner may be adapted to any type boiler. ***In the cross section*** fig. 8,954, the burner is seen to consist of two castings A and B, and three plates C, D and E. The bolting together of the castings and plates from the steam orifice K, and the oil orifice J. The outstanding feature of this burner is its *flexibility*, in that, by simply changing the plates, practically any type of flame may be obtained, either an extremely wide and short one, a long and narrow one, or a semi-conical one.

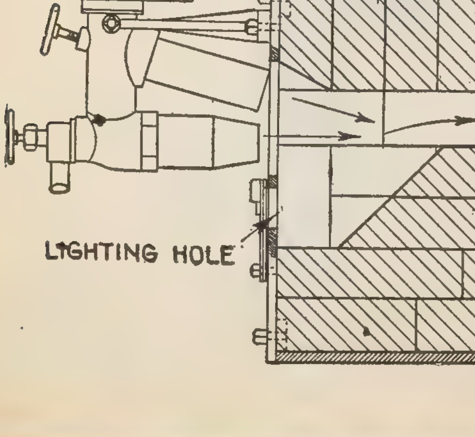


FIG. 8,955.—Macleod double vent oil burner and combustion box. The latter is provided with four bolting flanges to secure it to the side of the furnace. The oil is atomized, mixed and gasified before entering the furnace. ***In operation*** an extra jet of air is brought against the flame from the burner to secure better combustion.

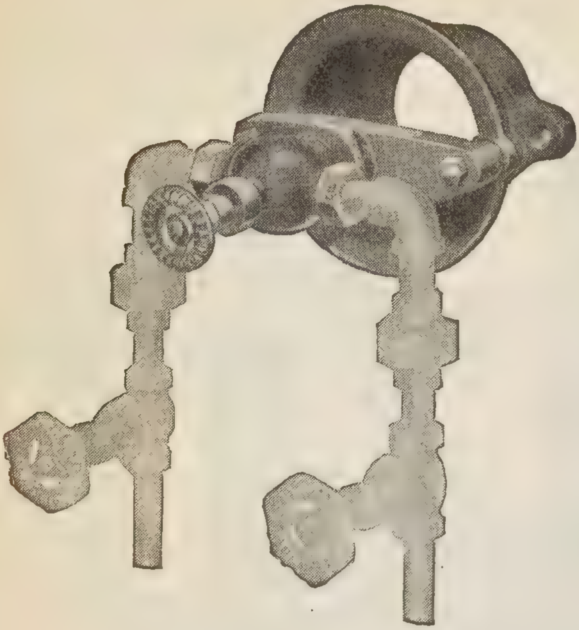


FIG. 8,956.—Tate-Jones No. 6 burner for high pressure air or steam installations. Where pressure in the proper ratio for the operation of No. 3 burner cannot be held, or where the air or steam is supplied at 50 lbs. and above, reduction being impractical, this burner is suited. It differs from the No. 3 in that the control of the oil and atomizing agent in this burner is separate. The oil supply is controlled by a needle valve in the burner proper and the air or steam is regulated by a suitable valve on the supply line. The burner will operate on 5 lbs. and above on the oil and 10 lbs. and above on the atomizing agent.

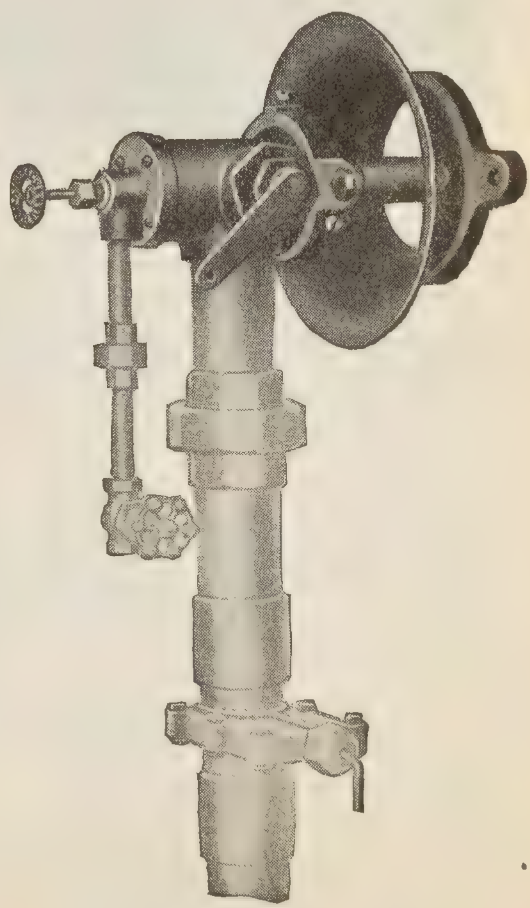


FIG. 8,957.—Tate-Jones positive pressure oil burner suitable where high pressures are not available. This burner operates on air at 1½ to 2 lbs., the air supply being controlled by the lever which moves through a 90 degree arc from a closed position to a full open position. In the closed position a slight amount of air is permitted to flow through the burner, keeping the tip cool and preventing carbonizing and burning off of the tip when the furnace is shut down. The oil supply is controlled by means of a needle valve at the end of a long stem operated by the handle shown on the end of the burner proper. The oil and air leave the tip of this burner in a finely mixed cone-shaped spray giving instantaneous and complete combustion.

this reason it is of the utmost importance that flue gas analysis be made frequently on oil burning boilers.

With the air for combustion properly regulated by adjustment of any checkerwork or any other device which may be used, and the dampers

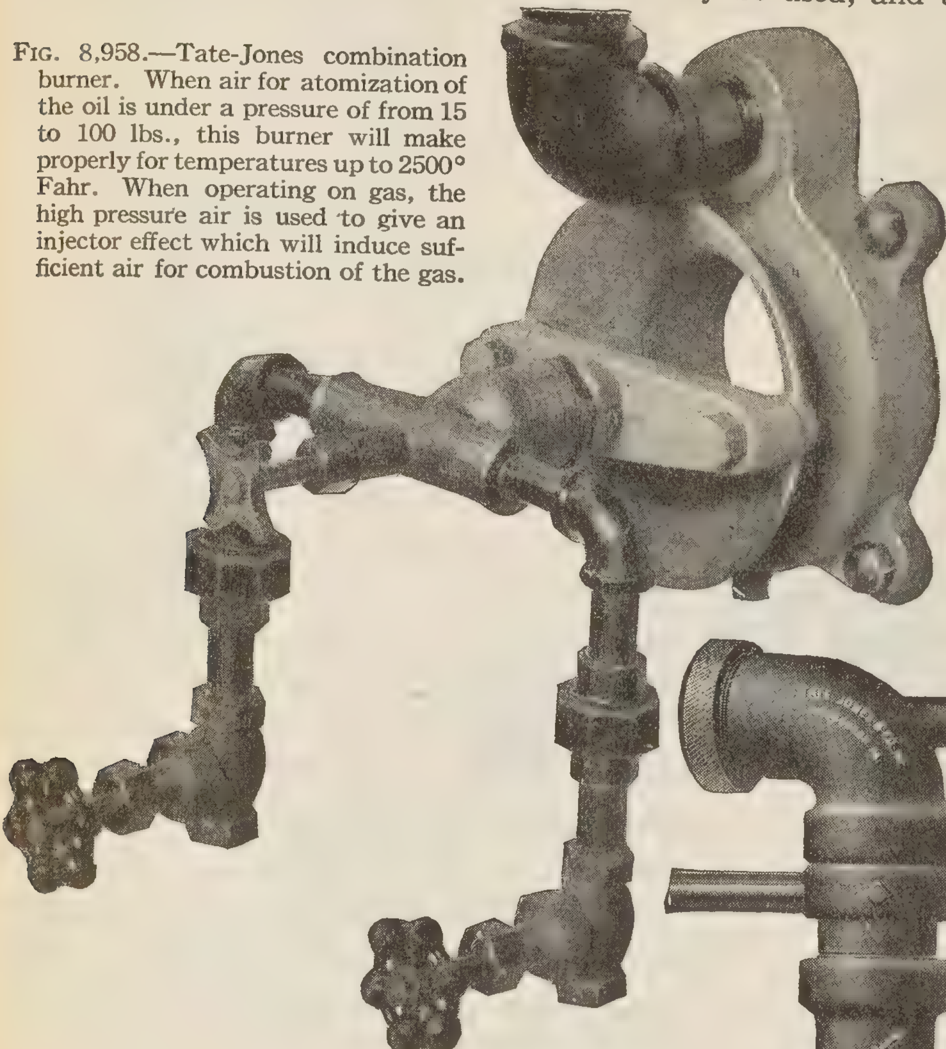


FIG. 8,958.—Tate-Jones combination burner. When air for atomization of the oil is under a pressure of from 15 to 100 lbs., this burner will make properly for temperatures up to 2500° Fahr. When operating on gas, the high pressure air is used to give an injector effect which will induce sufficient air for combustion of the gas.

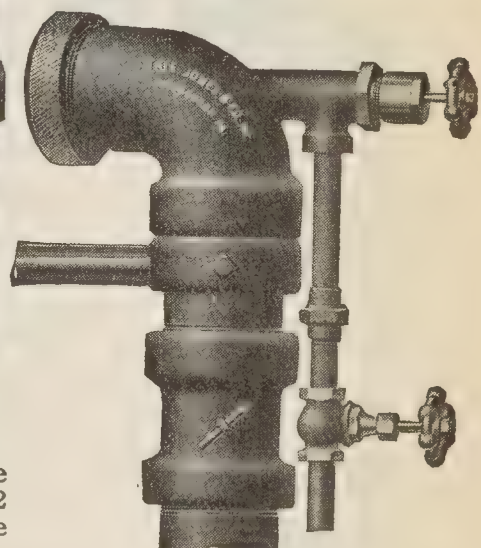
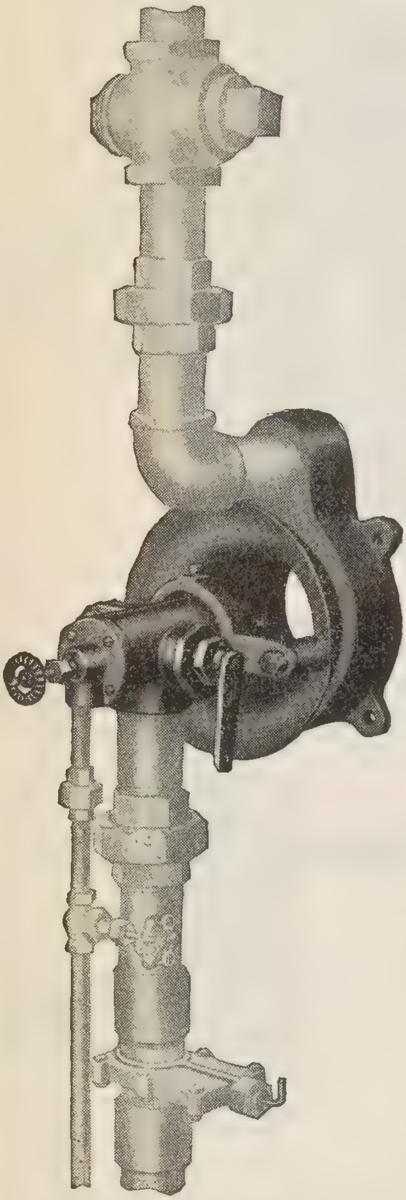


FIG. 8,959.—Tate-Jones fan blast burner for use where high pressures are not available. Operates on 10 to 12 ounces pressure. Adapted to heavy forging work where only the fan blast air is available. The oil supply is controlled by the small wheel valve and the air supply by the butterfly valve. ***In operation,*** the oil leaves the tip in a finely divided condition and is thoroughly mixed with the air which surrounds the oil nozzle. The atomization or breaking up of the oil is obtained by means of a mechanical spray nozzle tip, and it is this ultimate mixing of the fuel with the air that accomplishes complete combustion. A further air adjustment is obtained by the adjustable cap on the end which can be screwed in or out, thus changing velocity and direction of air flow.

carefully set, the flue gas analysis should show, for good furnace conditions, between 13 and 14 per cent, of CO_2, with either no CO or but a trace.

In boiler plant operation it is difficult to regulate the steam supply to the burners and the damper position to meet sudden and repeated variations in the load. A device has been patented which automatically regulates by means of the boiler pressure the pressure of the steam to the burners, the oil to the burners and the position of the boiler damper. Such a device has been shown to give good results in plant operation where hand regulation is difficult at best, and in many instances is unfortunately not even attempted.



Efficiency with Oil.—As pointed out in enumerating the advantages of oil fuel over coal, higher efficiencies are obtainable with the former. With boilers of approximately 500 horse power equipped with properly designed furnaces and burners, an efficiency of 83 per cent is possible or making an allowance of 2 per cent for steam used by burners, a net efficiency of 81 per cent. The conditions under which such efficiencies are to be secured are distinctly test conditions in which careful operation is a prime requisite.

With furnace conditions that are not conducive to the best combustion, this figure may be decreased by from 5 to 10 per cent.

In large properly designed plants, however, the first named efficiency may be approached for uniform running,

FIG. 8,960.—Tate-Jones combination positive pressure oil and gas burner. Where an air pressure of from 1½ to 2 lbs. is available, this burner will give satisfactory service, operating on gas under normal conditions and utilizing oil where the natural gas supply is low. ***In operating*** on gas, the oil supply is shut off and the air supply is used to provide for proper mixing and combustion of the gas.

conditions, the nearness to which it is reached depending on the intelligence of the operating crew.

It must be remembered that the use of oil fuel presents to the careless operator possibilities for wastefulness much greater

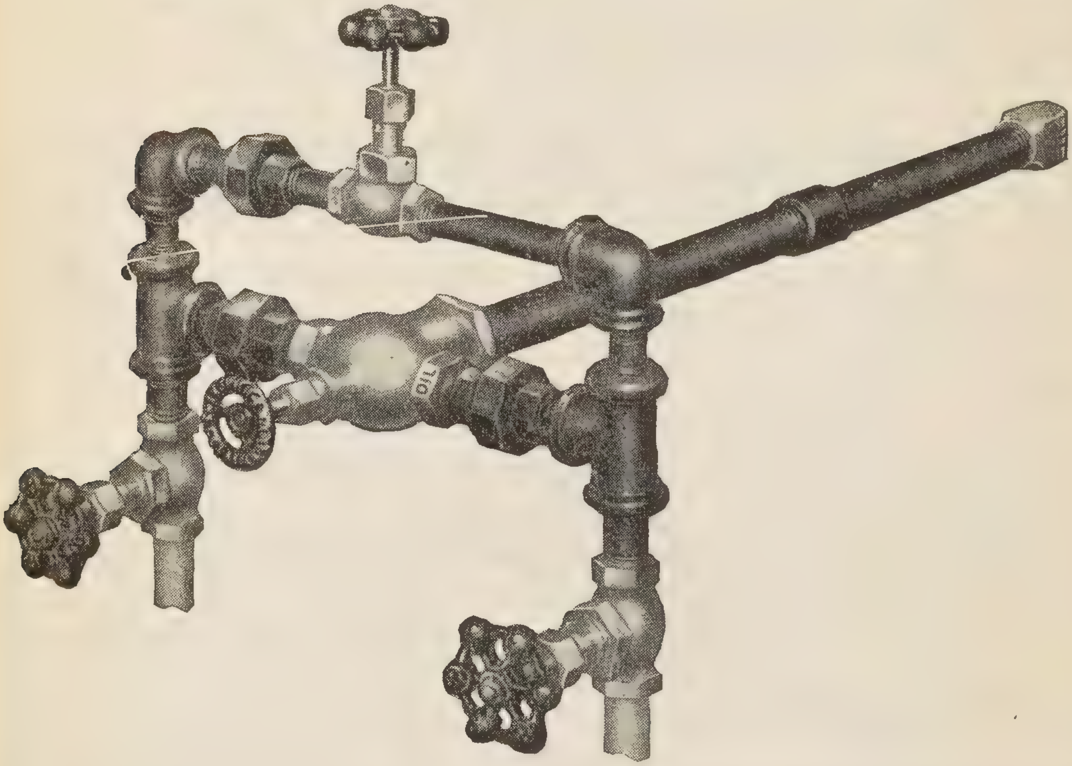


FIG. 8,961.—Tate-Jones oil burner for boiler work; especially adapted to power boilers. ***In operation,*** the type of burner shown above is particularly adapted for power boilers. The oil is atomized by means of steam, as naturally the steam is available. The expense of installing a compressor outfit is out of the question when compared with the amount of steam required, which should not exceed 2% of the steam developed. Full pressure on the oil is maintained up to the point where it is mixed with the steam within the burner. The steam ports of the mixer surround the oil ports and the finely broken up oil is thus maintained at practically the same temperature as the steam, entering the fire box in virtually a gaseous condition. The oil supply is controlled by a needle valve close to the nozzle, while the steam supply is regulated by a valve in the steam line close to the burner. Nozzle length and type of tip, broad or narrow spread, multiple slot or round hole are arranged to suit each particular installation, as successful results can best be obtained this way. A steam by pass is provided for blowing out oil passages.

than in plants where coal is fired, and it therefore pays to go carefully into this feature.

Burning Oil in Connection with Other Fuels.—Considerable

attention has been recently given to the burning of oil in connection with other fuels, and a combination of this sort may be advisable either with the view to increasing the boiler capacity to assist for heavy demands, or to keep the boiler in operation where there is the possibility of a temporary failure of the primary fuel.

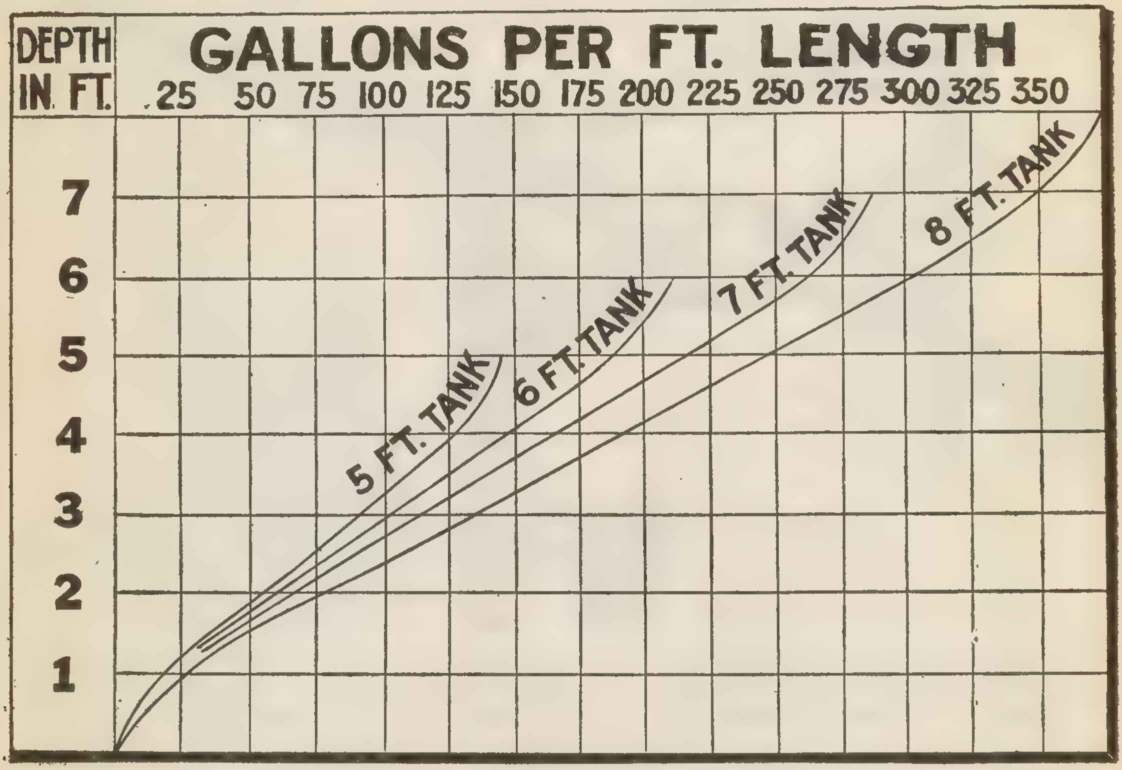


FIG. 8,962.—Chart for calculating the contents of partly filled horizontal, cylindrical tanks of 5, 6, 7 or 8 ft. diameter. ***How to read the chart:*** Where the measured depth in tank intersects the diameter as shown on the chart will be found the number of gallons for each foot in length.

CHAPTER 130

PLUMBING RULES

PLUMBING, DRAINAGE, WATER SUPPLY, GAS PIPING AND VENTILATION OF BUILDINGS.

Adopted by the Superintendents of Buildings, Effective April 23, 1912; Amended by the Board of Standards and Appeals, July 5, 1917; December 27, 1918; March 8, 1921; October 21, 1921, and January 8, 1924

Filing of Drawings, Descriptions, Etc.

1. Drawings and triplicate descriptions, on forms furnished by the Bureau of Buildings for all Plumbing and Drainage, shall be properly filled in, and filed by the owner or architect in the said Bureau. The plans must be drawn to scale in ink, on cloth, or they must be cloth prints of such scale drawings, and shall consist of such floor plans and sections as may be necessary to show clearly all plumbing work to be done, and must show partitions and methods of ventilating water-closet apartments.

2. The said plumbing and drainage shall not be commenced or proceeded with until said drawings and descriptions shall have been so filed and approved by the Superintendent of Buildings.

3. No modification of the approved drawings and descriptions will be permitted unless either amended drawings and triplicate descriptions, or an amendment to the original drawings and descriptions, covering the proposed change or changes, are so filed and approved by the Superintendent of Buildings.

4. The drainage and plumbing of all buildings, both public and private shall be executed in accordance with the rules and regulations of the Bureau of Buildings.

5. Repairs or alterations of plumbing or drainage may be made without filing drawings and descriptions in the Bureau of Buildings, but such repairs or alterations shall not be construed to include cases where new vertical lines or horizontal branches of soil, waste, vent or leader pipes are proposed to be used.

6. Notice of such repairs or alterations shall be given to the said bureau before the same are commenced in such cases as shall be prescribed by the rules and regulations of the said bureau, and the work shall be done in accordance with the said rules and regulations.

7. Where repairs or alterations, ordered by the Board of Health or Tenement House Department for sanitary reasons, include cases where new vertical and horizontal lines of soil, waste, vent or leader pipes are proposed to be used or old ones replaced, drawings and descriptions must be filed with and approved by the Superintendent of Buildings before same shall be commenced or proceeded with.

8. Repairs and alterations may comply in all respects with the weight, quality, arrangement and venting of the rest of the work in the building. Except when an existing soil, waste or vent line has been damaged by fire or other causes to the extent of 50 per cent or more of its entire length, same must be replaced by new lines installed in accordance with the rules and regulations governing new lines.

9. No plumbing and drainage or any part thereof shall be commenced until the plumber who is to do the work shall sign the specifications and make affidavit that he is duly authorized to proceed with the work. Affidavit must give the name and address of owner and plumber, etc. No registered plumber shall sign the specifications and act as the agent for a plumber who has not obtained a certificate of competency from the Examining Board of Plumbers as an Employing or Master Plumber. A violaton of this rule will be deemed a sufficient reason by the Superintendent of Buildings for the cancellation of a Certificate of Registration, in accordance with Chapter 803, Laws of 1896.

10. One set of specifications will be received for not more than ten houses, and then only when on adjoining lots and houses are exactly alike.

11. Written notices must be given to the Superintendent of Buildings by the plumber when any work is begun, and at such times as the work is ready for inspection.

Definition of Terms.

12. The term "private sewer" is applied to main sewers that are not constructed by and under the supervision of the Department of Public Works.

13. The term "house sewer" is applied to that part of the main drain or sewer extending from a point two feet outside of the outer front wall of the building, vault or area to its connection with public sewer, private sewer or cesspool.

14. The term "house drain" is applied to that part of the main horizontal drain and its branches inside the walls of the building, vault or area and extending to and connecting with the house sewer.

15. The term "soil line" is applied to any vertical line of pipe having outlets above the floor of first story for water closet connections.

16. The term "waste line" is applied to any vertical line of pipe having outlets above the first floor for fixtures other than water closet.

17. The term "vent pipe" is applied to any special pipe provided to ventilate the system of piping and to prevent trap siphonage and back pressure.

Materials and Workmanship.

18. All materials must be of the best quality, free from defects, and all work must be executed in a thorough, workmanlike manner.

19. All cast-iron pipes and fittings must be uncoated, sound, cylindrical and smooth, free from cracks, sand holes and other defects, and of uniform thickness.

20. Pipe, including the hub, shall weigh not less than the following average weights per linear foot:

Diameters	Weights per Linear Foot Standard	Extra Heavy	
2 inches	3 3/5	5½	pounds
3 inches	5 [illegible]/5	9½	pounds
4 inches	7	13	pounds
5 inches	9	17	pounds
6 inches	11	20	pounds
7 inches	14	27	pounds
8 inches	17	33½	pounds
10 inches	23	45	pounds
12 inches	33	54	pounds

Standard pipe may be used above ground in residence buildings not exceeding two stories and basement in height. In all other buildings extra heavy pipe shall be used.

21. The size, weight and maker's name must be cast on each length of pipe.

22. All joints must be made with picked oakum and molten lead and be made gas tight. Twelve ounces of fine, soft pig lead must be used at each joint for each inch in the diameter of the pipe when extra heavy pipe is used, and nine ounces when standard pipe is installed.

23. All wrought iron and steel pipes must be equal in quality to "standard" and must be properly tested by the manufacturer. All pipe must be lap-welded. No plain black or uncoated pipe will be permitted.

24. All wrought iron or steel water supply, vent, waste and soil pipes must be galvanized.

25. Where galvanized wrought iron or steel pipe is required the fittings used on same must also be galvanized.

26. Fittings for waste or soil and refrigerator waste pipes must be cast-iron recessed and threaded drainage fittings, with smooth interior waterway, and threads tapped, so as to give a uniform grace to branches of not less than one-fourth of an inch per foot.

27. Short nipples on wrought iron or steel pipe, where the unthreaded part of the pipe is less than one and one-half inches long, must be of the thickness and weight to correspond to weight of pipe.

28. The pipe shall not be less than the following average thickness and weight per linear foot:

Diameters	Thicknesses	Weights per Linear Foot
1½ inches	.14 inches	2.68 pounds
2 inches	.15 inches	3.61 pounds
2½ inches	.20 inches	5.74 pounds
3 inches	.21 inches	7.54 pounds
3½ inches	.22 inches	9.00 pounds
4 inches	.23 inches	10.66 pounds
4½ inches	.24 inches	12.34 pounds
5 inches	.25 inches	14.50 pounds
6 inches	.28 inches	18.76 pounds
7 inches	.30 inches	23.27 pounds
8 inches	.32 inches	28.18 pounds
9 inches	.34 inches	33.70 pounds
10 inches	.36 inches	40.06 pounds
11 inches	.37 inches	45.02 pounds
12 inches	.37 inches	48.98 pounds

29. All brass pipe for soil, waste and vent pipes and solder nipples must be thoroughly annealed, drawn, brass tubing, of standard iron-pipe gauge.

30. Connections on brass pipe, and between brass pipe and traps on iron pipe must not be made with slip joints or couplings. Threaded connections on brass pipe must be of the same size as iron pipe thread for same size of pipe and be tapered.

31. The following average thicknesses and weights per linear foot will be required:

Diameters	Thicknesses	Weights per Linear Foot
1½ inches	.14 inches	2.84 pounds
2 inches	.15 inches	3.82 pounds
2½ inches	.20 inches	6.08 pounds
3 inches	.21 inches	7.92 pounds
3½ inches	.22 inches	9.54 pounds
4 inches	.23 inches	11.29 pounds
4½ inches	.24 inches	13.08 pounds
5 inches	.25 inches	15.37 pounds
6 inches	.28 inches	19.88 pounds

32. Where light or heavy pipe is used brass ferrules must be of best quality cast brass, not less than 4 inches long and 2 inches and 3 inches and 4 inches in inside diameter and not less than the following weights:

Diameters	Weights	
2 inches	1 pound	0 ounces
3 inches	1 pound	12 ounces
4 inches	2 pounds	8 ounces

33. One and one-half inch ferrules are not permitted.

34. Soldering nipples must be heavy cast brass or of brass pipe, iron pipe size. When cast they must not be less than the following weights:

Diameters	Weights	
1½ inches	0 pounds	8 ounces
2 inches	0 pound	14 ounces
2½ inches	1 pound	6 ounces
3 inches	2 pounds	0 ounces
4 inches	3 pounds	8 ounces

35. Brass screw caps for cleanouts must be extra heavy, not less than one-eighth of an inch thick. The screw cap must have a solid square or hexagonal nut, not less than one inch high, with a least diameter of one and one-half inches. The body of the cleanout ferrule must be at least equal in weight and thickness to the caulking ferrule for the same size of pipe.

36. Where cleanouts are required by rules and by the approved plans, the screw cap must be of brass. The engaging part must have not less than six threads of iron pipe size and be tapered. Cleanouts must be of full size of trap up to four inches in diameter, and not less than four inches for larger traps.

37. The use of lead pipes is restricted to the short branches of the soil and waste pipes, bends and traps, roof connections of inside leaders.

"Short branches" of lead pipe shall be construed to mean not more than:

5 feet of	1½ inch pipe
5 feet of	2 inch pipe
2 feet of	3 inch pipe
2 feet of	4 inch pipe

38. All connections between lead pipes and between lead and brass or copper pipes must be made by means of "wiped" solder joint.

39. All lead waste, soil, vent and flush pipes must be of the best quality, known in commerce as "D," and of not less than the following weights per linear foot:

Diameters	Weights per Linear Foot
1¼ inch (for flush pipes only)	2½ pounds
1½ inches	3 pounds
2 inches	4 pounds
3 inches	6 pounds
4 and 4½ inches	8 pounds

40. All lead traps and bends must be of the same weights and thicknesses as their corresponding pipe branches. Sheet lead for roof flashings must be six-pound lead, and must extend not less than six inches from the pipe, and the joint made watertight.

41. Copper tubing, when used for inside leader roof connections, must be seamless drawn tubing, not less than 22 gauge, and when used for roof flashings must be not less than 18 gauge.

General Regulations.

42. Each building must be separately and independently connected with a public or private sewer, or cesspool, except where a building is located on the rear of the same lot with another building, when its plumbing and drainage system may be connected to the house-drain of the front building behind the house trap and fresh air inlet which shall be used for both buildings if sewer connected; or may be connected to an existing cesspool of front house and be provided with a separate house trap and fresh air inlet.

43. Every building must have its sewer connections directly in front of the building, unless permission is otherwise granted by the Superintendent of Buildings.

44. Where there is no sewer in the street or avenue, and it is possible to construct a private sewer to connect in an adjacent street or avenue, a private sewer may be constructed, to be used in common for one or more buildings. It must be laid outside the curb under the roadway.

45. Cesspool and privy vaults will be permitted only after it has been shown to the satisfaction of the Superintendent of Buildings that their use is absolutely necessary.

46. When allowed, they must be constructed strictly in accordance with the terms of the permit issued by the Superintendent of Buildings.

47. Cesspools must not be used as privy vaults nor can privy vaults be used as cesspools. Cesspools and privy vaults must be located at least 15 feet from any building and on the same lot as building for which their use is intended. Walls of cesspools and privy vaults when constructed of brick must be 8 inches thick; if of stone, 18 inches thick. Bottoms of cesspools and privy vaults must be of stone concrete 6 inches thick. The entire interior surface of cesspools and privy vaults must be finished with a coating of Portland cement mortar 1 inch thick.

48. As soon as it is possible to connect with a public sewer, the owner must have the cesspool and privy vault emptied, cleaned and disinfected and filled with fresh earth, and have a sewer connection made in the manner herewith prescribed.

49. All pipe lines must be supported at the base on brick piers, or by heavy iron hangers from the cellar ceiling-beams, and along the line by heavy iron hangers at intervals of not more than ten feet.

50. All pipes, issuing from extensions or elsewhere, which would otherwise open within 20 feet of the window of any building, must be extended above the top of any window located within such distance. When a building exceeds in height that of an adjoining building, and windows or openings are cut in the wall on the lot line within 20 feet of the roof terminal of any soil, waste or vent line now in place or subsequently installed in the lower building, the owner of the higher building shall defray the expense of extending said soil, waste or vent lines above the roof of the higher building, or shall himself make such alteration.

51. The arrangement of all pipes must be as straight and direct as possible. Offsets will be permitted only when unavoidable.

52. All pipes and traps should, where possible, be exposed to view. They should always be readily accessible for inspection and repairing.

53. In every building where there is a leader connected to the drain, if there are any plumbing fixtures, there must be at least one four (4) inch pipe extending above the roof for ventilation.

Yard, Area and Other Drains.

54. All yards, areas and courts exceeding 15 square feet in area must be drained into the sewer. A shaft open at the top not exceeding 25 square feet in area, and which cannot be connected in back of a leader, yard, court or area drain trap, may be drained into a publicly-placed, water-supplied, properly-trapped and vented slop sink.

55. These drains, when sewer-connected, must have connections not less than three inches in diameter. They should be controlled by one trap—the leader trap, if possible.

56. Floor drains will only be permitted when it can be shown to the satisfaction of the Superintendent of Buildings that their use is absolutely necessary and arrangements made to maintain a permanent water seal in the traps.

57. Cellar drains may be connected in back of and controlled by a leader, yard, court or area drain trap which need not be vented.

58. Subsoil drains should discharge into a sump or receiving tank, the contents of which if discharged by gravity may be discharged into a rain leader, yard, court or area drain behind the trap controlling same or may be discharged through a properly-trapped and vented, water-supplied receptacle. Where mechanical force is required to discharge the contents into the plumbing and drainage system, a proper automatic cut-off or check valve must be provided on the connection between house-drain and apparatus used for raising the contents of sump-pit.

59. The contents of settling chamber or dust receptacle for vacuum cleaners may be discharged into a Plumbing and Drainage system, the same as sub-soil drain sump-pits.

Leaders.

60. Every building shall be kept provided with proper metallic gutters and rain leaders for conducting water from all roofs in such manner as shall protect the walls and foundations from injury. In no case shall the water from any rain leader be allowed to flow upon the sidewalk or adjoining property, but the same shall be conducted by proper pipes to the sewer. If there be no sewer in the street upon which the building fronts, then the water from said leaders may be conducted by proper pipes laid below the surface of sidewalk to the street gutter, or may be conducted by extra heavy cast-iron pipe to a leeching cesspool located at least 20 feet from any building. No plumbing fixtures shall discharge into a leeching cesspool.

61. Inside leaders must be made of cast-iron, wrought-iron or steel, with roof connections made gas and water tight by means of a heavy lead or copper-drawn tubing wiped to a brass ferrule or nipple caulked or screwed into the pipe.

62. Outside leaders may be made of sheet metal, but they must connect with the house drain by means of a cast-iron pipe extending vertically five feet above the grade level.

63. Leaders must be trapped with cast-iron running traps so placed as to prevent freezing.

64. Rain-water leaders must not be used as soil, waste or vent pipes, nor shall any such pipe be used as a leader,

The House Sewer, House Drain, House Trap and Fresh Air Inlet.

65. Old house sewers may be used in connection with new buildings or new plumbing only when they are found, on examination by the plumbing inspector, to conform in all respects to the requirements governing new sewers.

66. When a proper foundation consisting of a natural bed of earth, rock, etc., can be obtained, the house sewer can be of earthenware pipe.

67. Where the ground is made or filled in, or where the pipes are less than three feet deep, or in any case where there is danger of settlement by frost or from any cause, and when cesspools are used, the house sewer must be of extra heavy cast-iron pipe, with lead-caulked joints.

68. No earthenware house drain, when found in a leaky or defective condition, shall be repaired or replaced except with heavy cast-iron pipe.

69. The house drain and its branches must be of extra heavy cast iron when under ground, and of extra heavy cast iron or galvanized wrought iron or steel when above ground, except as provided in Rule 20 of these rules.

70. The house drain must properly connect with the house sewer at a point two feet outside of the outer front vault or area wall of the building. An

arched or other proper opening must be provided for the drain in the wall to prevent damage by settlement.

71. The house drain if above the cellar floor must be suported at intervals of ten feet by eight-inch brick piers or suspended from the floor beams, or be otherwise properly supported by proper hangers placed not more than 10 feet apart.

72. No steam-exhaust, boiler blow-off or drip-pipe shall be connected with the house-drain. Such pipes must first discharge into a proper condensing tank, and from this a proper outlet to the house sewer outside of the building must be provided. In low pressure steam systems the condensing tank may be omitted, but the waste connections must be otherwise as above required.

73. The house-drain and house sewer must be run as direct as possible, with a fall of at least one-quarter inch per foot, all changes in direction made with proper fittings, and all connections made with Y branches and one-eighth and one-sixteenth bends.

74. The house-sewer and house-drain must be at least four inches in diameter when receiving the discharge of a water-closet. Where rain leaders are connected to the plumbing system, the sizes of house-sewer, house-drain and leader connections shall be computed according to the square feet of area drained into them. No house-sewer or house-drain shall be of less diameter than the largest line of pipe connected thereon. The following table is the maximum area allowed to drain into pipes of given diameter:

Diameter of Pipe	Fall ¼ Inch per Foot	Fall ½ Inch per Foot
3	1,200 square feet	1,500 square feet
4	2,500 square feet	3,200 square feet
5	4,500 square feet	6,000 square feet
6	8,000 square feet	10,000 square feet
7	12,400 square feet	15,600 square feet
8	18,000 square feet	22,500 square feet
9	25,000 square feet	31,500 square feet
10	41,000 square feet	59,000 square feet
12	69,000 square feet	98,000 square feet

75. Full size Y and T branch fittings for handhole cleanouts must be provided where required on house-drain and its branches. No cleanout need be larger than 6 inches in diameter.

76. An iron running trap must be placed in the house-drain near the front wall of the house, and on the sewer side of all connections, except a Y fitting used to receive the discharge from an automatic sewage lift, oil separator, or a drip-pipe where one is used. If placed outside of the house or below the

cellar floor, it must be made accessible in a brick manhole, the walls of which must be eight inches thick, with an iron or flagstone cover. When outside the house it must never be less than three feet below the surface of the ground.

77. When the plumbing system of any building is altered by the addition of a new soil, waste or vent line to the extent of 50 per cent. or more, and no house trap and fresh air inlet or leader trap exists on the house-drain, same shall be provided.

78. The house trap must have two cleanouts, with brass screw cap ferrules caulked in.

79. A fresh-air inlet pipe must be connected with the house-drain just inside of the house trap and extended to the outer air, terminating with open end at least one foot above the grade at most available point to be approved by the Superintendent of Buildings and shown on plans. The fresh-air inlet pipe shall be one-half the diameter of house-drain but not less than 4 inches in diameter.

80. No curb box or similar device with grating placed in sidewalk will be permitted for fresh air inlets.

Soil and Waste Lines.

81. All main, soil, waste or vent pipes must be of iron, steel or brass.

82. When they receive the discharge of fixtures on any floor above the first, they must be extended in full calibre at least one foot above the roof coping, and well away from all shafts, windows, chimneys or other ventilating openings. When less than four inches in diameter, they must be enlarged to four inches at a point not less than one foot below the roof surface by an increaser not less than nine (9) inches long.

83. No caps, cowls or bends shall be affixed to the top of such stack.

84. In all buildings, wire baskets must be securely fastened into the opening of each pipe in an accessible position. When roofs are used for drying purposes or roof gardens, all pipes shall be extended to a height of seven feet.

85. Necessary offsets above the highest fixture branch must not be made at an angle of less than forty-five degrees to the horizontal.

86. Soil and waste pipes must have proper Y or TY branches for all fixture connections.

87. No connection to lead branches for water-closets or slop sinks will be permitted, except the required branch vent.

88. Branch soil and waste pipe must have a fall of at least one-quarter inch per foot.

89. Short TY branches will be permitted on vertical lines only. Long one-quarter bends and long TY's are permitted. Short one-quarter bends and double hubs, short roof increasers and common offsets, and bands and saddles are prohibited.

90. The diameters of soil and waste pipes must not be less than those given in the following table:

Main soil stacks in buildings serving not more than two sets of fixtures in four or less stories	4	inches
Main soil stacks in residence buildings serving not more than two sets of fixtures in five or six stories	4	inches
Main soil stacks in all other cases	5	inches
Branch soil pipes for not more than four water-closets	3	inches
Branch soil pipes for more than four water-closets	4	inches
Main waste stacks	2	inches
Main waste stacks for kitchen sinks on six on more floors	3	inches
Branch waste pipes for slop sinks	3	inches
Branch waste pipes for laundry tubs	1½	inches
When set in ranges of three	2	inches
Branch waste for kitchen sinks	2	inches
Branch waste for urinals	2	inches
Branch waste for other fixtures	1½	inches

A set of fixtures, as used in this rule, shall include not more than one water-closet, one bath tub, one wash basin, one sink and two laundry trays.

Vent Pipes.

91. All traps, except approved anti-siphon traps connected to main waste or soil lines or to the house drain by branch piping not over seven (7) feet in length with a fall not exceeding two (2) inches per foot, shall be protected from siphonage and back-pressure by special lines of vent pipes; provided that where approved deep-seal siphon-jet water closet or slop sink fixtures are installed with branch piping not over five (5) feet in length from fixture to main soil or waste line, the vent pipe may be omitted for such fixtures in buildings not over eight (8) stories in height, and where the main soil or waste line is made one inch larger in diameter than required by these rules, the vent pipe may also be omitted for such fixtures in buildings over eight (8) stories in height.

92. All vent pipe lines and main branches must be of iron, steel or brass. They must be increased in diameter and extended above the roof as required for waste pipes. They may be connected with the adjoining soil or waste line well above the highest fixture, but this will not be permitted when there are fixtures on more than six floors.

93. All offsets must be made at an angle of not less than forty-five degrees to the horizontal, and all lines must be connected at the bottom with a soil or waste pipe or the drain in such a manner as to prevent the accumulation of rust scale.

94. Branch vent pipes shall be kept above the top of all connectng fixtures, so as to prevent the use of vent pipes as soil pipes or waste pipes. Branch vent pipes should be connected not less than six inches nor more than two feet from crown of trap or side of lead bend.

95 Except where "yoke type" ventilation is installed, vent connection for water-closets and slop sinks must be made from the branch soil or waste pipe just below the trap of the fixture, and the branch vent pipe must be so connected as to prevent obstruction, and no waste pipe connected between it and the fixture. Earthenware traps must have no vent horns.

· "Yoke type" ventilation shall be taken to mean a cross connection, by means of a horizontal branch soil or waste pipe, between the main soil or waste line and the vent line, and in which the connection between the branch pipe and the vent line is made at least six (6) inches above the line of fixtures discharging into such branch pipe.

96. No sheet metal, brick or other flue shall be used as a vent pipe.

97. The sizes of vent pipes throughout must not be less than the following:

For main vents, two inches in diameter; for water-closets on three or more floors, three inches in diameter; for other fixtures on less than seven floors, two inches in diameter; three-inch vent pipe will be permitted for less than nine stories; for more than eight and less than sixteen stories, four inches in diameter; for more than fifteen and less than twenty-two stories, five inches in diameter; for more than twenty stories the size of the vent pipe shall be determined by the Superintendent of Buildings.

For fixtures other than water-closets and slop sinks and for more than eight stories, vent pipes may be one inch smaller in diameter than above stated.

For long branch vent pipes over 10 feet in length but not exceeding 25 feet, two inches in diameter; when over 25 feet in length but not exceeding 50 feet, three inches in diameter. No branch vent pipe can exceed 50 feet in length, nor can any main vent be of less diameter than the largest branch vent connecting to same.

98. When the plumbing fixtures installed in any building are arranged in groups or batteries, "yoke type" ventilation may be installed, provided that for batteries of water-closets each fixture shall be set not more than two (2) feet distant from the horizontal branch soil pipe into which it discharges, and for batteries of fixtures other than water-closets each fixture shall be so located that its trap will be not more than two (2) feet distant from the horizontal branch waste line into which it discharges. When the ordinary type of venting is installed and the number of branch or back vents from the traps of fixtures connecting to any main branch vent exceeds the number and size given in the following table, a 3-inch main branch vent must be provided for the additional vent connections.

2-1½ inch branches on a 1½ inch main branch.	
4-2 inch branches on a 2 inch main branch.	
7-1½ inch branches on a 2 inch main branch.	
2-2 4-1½	inch branches on a 2 inch main branch.
1-2 5-1½	inch branches on a 2 inch main branch.

Traps.

99. No form of trap will be permitted to be used unless it has been approved by the Superintendent of Buildings or the Board of Standards and Appeals.

No anti-siphon trap or deep-seal siphon-jet fixture shall be approved until it has successfully passed such test as may be prescribed by the Board of Standards and Appeals.

100. No masons' cesspool, bell, pot, bottle or D-trap will be permitted, nor any form of trap that is not self-cleaning, nor that has interior chamber or mechanism, nor any trap except earthenware ones that depend upon interior partitions for a seal. Backwater or tide valves will only be permitted when it can be shown to the satisfaction of the Superintendent of Buildings that their use is absolutely necessary and of a type as approved by him.

101. Every fixture must be separately trapped by a water-sealing trap placed as close to the fixture outlet as possible, and no trap shall be placed more than 2 feet 0 inches from any fixture.

102. A set of not more than three wash trays may connect with a single trap, or into the trap of an adjoining sink, provided both sink and tub waste outlets are on the same side of the waste line, and the sink is nearest the line. When so connected, the waste pipe from the wash trays must be branched in below the water-seal.

103. The discharge from any fixture must not pass through more than one trap before reaching the house-drain.

104. All traps must be well supported and set true with respect to their water levels.

105. All fixtures, other than water-closets and urinals, must have strong metallic strainers or bars over the outlets to prevent obstruction of the waste pipe.

106. All exposed or accessible traps, except water-closet traps, must have brass trap screws for cleaning the trap placed on the inlet side, or below the water level.

107. All iron traps for house-drain, yard and other drains and leaders must be running traps with handhole cleanouts of full size of the traps, when same are less than five (5) inches. All traps under ground must be made accessible by brick manholes with proper covers.

108. Overflow pipes from fixtures must in all cases be connected on the inlet side of traps.

109. All earthenware traps must have approved heavy brass floor plates properly secured to the branch soil pipe and bolted to the trap flange, and the joint made gas-tight. The use of rubber washers for floor connections is prohibited. All floor flanges must be set in place and inspected before any water-closet is set thereon.

110. No trap shall be placed at the foot of main soil and waste pipe lines.

111. Every plunge bath shall be provided with a trap at least four inches in diameter, the waste from trap to bath to be reduced to two inches in diam-

eter and this waste to be controlled by a gate valve. Overflow pipes, if provided must be connected on inlet side of trap. Except where an approved anti-siphon trap is installed in the manner specified in Rule 91, such trap must be ventilated by a separate vent line extended above the roof, of the same size as trap and water connection.

112. The sizes for traps must not be less than those given in the following table:

Traps for water-closets	4	inches in diameter
Traps for slop sinks	3	inches in diameter
Traps for kitchen sinks	2	inches in diameter
Traps for wash trays	2	inches in diameter
Traps for urinals	2	inches in diameter
Traps for shower-baths	2	inches in diameter
Traps for other fixtures	1½	inches in diameter

Traps for leaders, area, floor and other drains must be at least 3 inches in diameter.

113. Every dental cuspidor must be separately trapped by a trap of at least one and one-half (1½) inches in diameter, which shall be vented except where an approved anti-siphon trap is installed in the manner specified in Rule 91, and placed as close to the fixture as possible. The connection between trap and cuspidor may be three-quarters (¾) of an inch in diameter.

114. No plumbing fixtures, except bar sinks, soda fountains or drinking fountains, shall be installed with an indirect waste connection to the plumbing and drainage system. The waste of every bar sink, soda fountain and drinking fountain, if not directly connected, must discharge over a properly water-supplied, trapped sink, with trap vented, unless an approved anti-siphon trap is installed in the manner specified in Rule 91. The main waste lines shall be two (2) inches in diameter, and the branches to fixtures at least one and one-half (1½) inches in diameter. Drinking fountains must be trapped and the waste line extended through the roof. No vent connections need be provided.

Safe and Refrigerator Waste Pipes.

115. Safe and refrigerator waste pipes must be of galvanized iron, and be not less than 1¼ inches in diameter nor larger than 1½ inches in diameter with pipe branches at least 1 inch in diameter with strainers over each inlet.

116. Safe and refrigerator waste pipes shall not be trapped. They must discharge over a properly water-supplied, trapped sink, with trap vented unless an approved anti-siphon trap is installed in the manner specified in Rule 91, such sink to be publicly placed, and not more than 4 feet above the floor. In no case shall any refrigerator or safe waste pipe discharge over a sink located in a room used for living purposes.

117. The branches on vertical lines must be made by Y or TY fittings and carried up to the safe with as much pitch as possible.

118. Lead safes must be graded and neatly turned over bevel strips at their edges.

119. Where there is an offset on a refrigerator waste pipe in the cellar, there must be cleanouts to control the horizontal part of the pipe.

120. In all lodgings and tenement houses the safe and refrigerator waste pipes must extend above the roof.

Water Closets, Sinks and Washtubs.

(*Good except as relating to tenement houses and factories.*)

121. In all buildings occupied as stores, dwellings, lodging or boarding houses, hotels, offices, lofts, workshops, factories or storage houses, there must be at least one water-closet in each building. There must be sufficient water-closets so that there will never be more than 15 persons to each water-closet. In places of public assembly, the number of toilets and the most available location are to be determined by the Superintendent of Buildings.

122. Separate water-closets and toilet rooms must be provided for each sex in buildings used as workshops, lofts, office buildings, factories, hotels, and all places of public assembly.

123. In lodging houses, there must be one water-closet on each floor, and where there are more than 15 persons on any floor there must be an additional water-closet on that floor for every 15 additional persons or fraction therof.

124. In tenement houses, lodging houses, factories, workshops, and all public buildings, the entire water-closet apartment, and side walls to a height of six inches from the floor, except at the door, must be made waterproof with asphalt, cement, tile, metal or other waterproof material as approved by the Superintendent of Buildings.

125. In all buildings, the water-closet and urinal apartments must be ventilated to the outer air by windows opening on the same lot upon which the building is situated or by a ventilating skylight placed over each room or apartment wherein such fixtures are located.

126. In all buildings, the outside partition of any water-closet or urinal apartment must be air-tight and extend to the ceiling or be independently ceiled over. When necessary to properly light such apartments, the upper part of the partitions must be provided with translucent glass. The interior partitions of such apartments must be dwarfed partitions.

127. The general water-closet accommodation of any building cannot be placed in the cellar, nor can any water-closet be placed outside of a building except to replace an existing water-closet.

128. In alteration work where it is not practicable to ventilate a water-closet or urinal apartment by windows or a skylight directly to the outer air, there may be provided a galvanized wrought iron vent duct extended to the outer air which must be equal in area to at least 144 inches for one water-closet or urinal, and an additional 72 square inches for each water-closet added therein.

129. Where water-closets will not support a rim-seat, the seat must be supported on galvanized iron legs.

130. Every earthenware water-closet with connection through the floor in all new work, and in all alterations, must be set on an approved floor slab of porcelain, slate or other material impervious to moisture, same to be not less in size than the base of the water-closet set thereon.

131. All water-closets must have earthenware flushing rim bowls. They must be set entirely free and open from all enclosing woodwork.

132. Pan, plunger, offset-washout and washout, or other water-closets having an unventilated space, or the walls of which are not thoroughly washed out at each discharge, will not be permitted.

133. Long hopper water-closets will not be permitted, except earthenware hoppers where there is an exposure to frost.

134. Drip trays on water-closets will not be permitted.

135. Water-closets and urinals must never be connected directly with or flushed from the water-supply pipes, except when flushometer valves are used.

136. Each water-closet and urinal must be flushed from a separate cistern, the water from which is used for no other purpose, or may be flushed through flushometer valves.

137. Where "Flushometers" are used, they must be supplied from tank pressure, unless otherwise permitted by the Superintendent of Buildings; the rising lines shall be at least one and one-half inches in diameter, and the main branches shall be at least one and one-quarter inches in diameter, with individual branches not less than one inch in diameter, for water-closets and not less than one-half inch in diameter for urinals. Individual branches shall not exceed twelve inches in length.

138. The overflow of cisterns may discharge into the bowl of the closet, but in no case connect with any part of the drainage system.

139. Iron water-closet and urinal cisterns and automatic water-closet and urinal cisterns are prohibited, unless approved by the Superintendent of Buildings.

140. The copper lining of water-closet and urinal cisterns must not be lighter than ten (10) ounce copper.

141. Water-closet flush pipes must not be less than one and one-fourth inches and urinal flush pipes one (1) inch in diameter, and if of lead must not weigh less than two and one-half pounds and two pounds per linear foot. Flush couplings must be of full size of the pipe.

142. Rubber connections and elbows are not permitted on flush pipes.

143. Latrines, trough water-closets and similar appliances may be used only on written permit from the Superintendent of Buildings, and must be set and arranged as may be required by the terms of the permit.

144. All urinals must be constructed of materials impervious to moisture, and that will not corrode under the action of urine. The floor and wall of the urinal apartments must be lined with similar non-absorbent and non-corrosive material.

145. The platforms of treads of urinal stalls must never be connected independently to the plumbing system, nor can they be connected to any safe waste pipe.

146. Iron trough water-closets and trough urinals must be enameled or galvanized.

147. In all houses, sinks must be entirely open, on iron legs or brackets without any inclosing woodwork.

148. Wooden wash tubs are prohibited, except when used in hotels, restaurants or bottling establishments for washing dishes or bottles. Cement or artificial stone tubs will not be permitted unless approved by the Superintendent of Buildings.

Water Supply for Fixtures.

149. All water-closets and other plumbing fixtures must be provided with a sufficient supply of water for flushing to keep them in a proper and cleanly condition.

Flush tanks must have a capacity of eight gallons for water-closets and five gallons for urinals.

150. House service pipes must be connected to the street mains by means of taps, and a stop-cock or valve placed under the sidewalk at the curb, in compliance with the rules and under the supervision of the Department of Water Supply, Gas and Electricity.

151. A separate stop or valve must be placed upon the service pipe inside the front wall.

152. The diameters of street service pipes must not be less than three-quarter inch for dwellings and tenements occupied by six families or less; one inch for tenements or apartment houses occupied by more than six families and one and one-half inch for hotels, factories and other miscellaneous buildings, provided that in no case can the diameter of the service pipes be less than the diameter of the tap installed under the supervision of the Department of Water Supply, Gas and Electricity.

Riser Lines.

153. The diameter of all riser lines in plumbing systems shall be not less than three-quarters (¾) inches; except that when lead or brass pipe is used, the minimum diameter may be one-half (½) inch.

Separate stop-cocks or valves, so located as to be accessible at all times, shall be placed at the foot of each riser line and, in all buildings other than residence buildings occupied exclusively by one or two families or having not more than fifteen sleeping rooms, on each branch line from the riser for each isolated fixture or each group of fixtures, such as bathroom fixtures, kitchen fixtures, etc.; except that only one stop cock or valve shall be required for the fixtures contained in any one apartment, suite, store or loft occupied by one tenant when all the fixtures contained in each such apartment, suite, store or loft are supplied from one branch line.

154. Diameters of branches to any fixtures must not be less than one-half inch, except when used to supply water-closets, cisterns or lavatories. When

the material used is lead or brass pipe, the minimum diameter may be three-eighths inch. Branches for flush valves for water-closets must not be less than one and one-quarter inch in diameter and for urinals not less than three-quarters of an inch in diameter.

155. Where a hot water supply system is installed, the distance between the hot and cold water risers should not be less than six inches. Where it is impossible to place them six inches or more apart, the hot water riser must be covered with an approved insulating material and a method of circulation provided that will insure a prompt delivery of hot water at the faucet when required.

156. All risers and branches must be properly fastened.

157. When the water pressure is not sufficient to supply freely and continuously all fixtures, a house supply tank must be provided of sufficient size to afford an ample supply of water to all fixtures at all times. Such tanks must be supplied from the pressure or by power pumps, as may be necessary; when from the pressure, ball cocks must be provided.

158. House supply tanks must be metal-covered so as to exclude dust and so located as to prevent water contamination by gas and odors from plumbing fixtures.

159. House supply tanks must be of wood or iron, or of wood lined with tinned and planished copper.

160. House tanks must be supported on iron beams.

161. The overflow pipe should discharge upon the roof, where possible, and in such cases should be brought down to within six (6) inches of the roof, or it must be trapped and discharged over an open and water-supplied sink not in the same room, nor over three and one-half feet above the floor. In no case shall the overflow be connected with any part of the plumbing system.

162. Emptying pipes for such tanks must be provided and be discharged in the manner required for overflow pipes, and may be branched into overflow pipes. Emptying pipes for tanks containing more than five hundred (500) gallons must be four (4) inches in diameter and provided with a valve of same size fitted with a wheel or lever handle.

163. Acid wastes must be "B" lead pipe or earthen pipe; if of lead pipe they must be at least two inches in diameter, and if of earthen pipe at least three inches in diameter. They must be extended through roof for ventilation and continued down to the lower story of building and so arranged as to discharge into a lime box and diluting sink properly trapped and vented and connected inside of house trap. If the lime box and diluting sink are not used the acid waste must be extended to an earthen house sewer or separately and independently connected to a public or private sewer in street and provided with an accessible running trap located just inside of front wall of building. All branches and joints on lead acid wastes must be made by means of burnt lead joints. If earthenware pipe is used, vertical joints must be made with a mixture of asphaltum and cement. Each length of pipe on vertical runs and on horizontal runs when above the cellar floor must be supported at each hub by proper supports. All floor drains and fixture connections must be trapped and run as direct as possible.

Sewage Lifts.

164. When it is necessary to use a sump system and sewage lift to receive the discharge from the waste or soil connection to fixtures, same shall be arranged to be accessible. If discharged with compressed air it shall be connected to the house drain on the sewer side of all leader or area drain traps and fixture connections or may be connected to house drain on the sewer side of house trap. A separate trap and fresh air inlet must be provided on the inlet side of sump and a 4-inch pipe line continued from drain discharging into sump up to and above roof, for purposes of ventilation. Relief pipes must be provided on sewage receptacles of sumps. Traps of fixtures connected to sump systems must not be vented to vent lines which are used to ventilate traps of fixtures on gravity system. Sump systems should be entirely separate both as to discharge and venting from rest of plumbing system in buildings.

Oil Separators.

165. Oil separators installed in any building where volatile fluids are used must be arranged to be readily accessible. They must not receive the discharge of any water-closet, rain leader, yard, court or area drain.

166. They must, if discharged by gravity, be connected by a Y branch fitting to the house drain behind the house trap in such a manner that they will not interfere with the house drain and the rest of the plumbing and drainage system. When mechanical force is used to discharge the contents, the connection must be made by a Y branch fitting on the sewer side of house trap.

167. No separate running trap need be provided on the drain entering oil separators, but a separate fresh air inlet and vent line must be provided to keep the system of drainage controlled by the oil separator entirely separate from the rest of plumbing and drainage system.

168. The size of fresh air inlet shall be determined by the size of inlet connection to oil separator, which shall be considered the same as the term house-drain for determining the size of all fresh air inlets, which shall conform to the same requirements as regards size and arrangement of terminals for fresh air inlets as called for in regulations.

169. Vent lines shall conform in all respects to vent lines for plumbing fixtures as regards size and arrangement.

170. Relief pipes must be provided at least 1½ inches in diameter. They may be connected to a vent line when installed as a separate system or must be carried independently above the roof.

Testing the Plumbing System.

171. The entire plumbing and drainage system within the building must be tested by the plumber, in the presence of a Plumbing Inspector, under a water test. All pipes must remain uncovered in every part until they have successfully passed the test. The plumber must securely close all openings, as directed by the Inspector of Plumbing. The use of wooden plugs for this purpose is prohibited.

172. The water test will be applied by closing the lower end of the main house drain and filling the pipes to the highest opening above the roof with water. The water test shall include at one time the house drain and branches, all vertical and horizontal soil, waste and vent and leader lines and all branches therefrom to a point above the surface of the finished floor and beyond the finished face of walls and partitions. If the drain or any part of the system is to be tested separately, there must be a head of water at least six (6) feet above all parts of the work so tested, and special provision must be made for including all joints and connections in at least one test.

173. After the completion of the plumbing work in any new or altered building and before the building is occupied, a final smoke test must be applied in the presence of a Plumbing Inspector. Except that for a building not over six stories in height, a peppermint test may be applied.

174. The material and labor for the test must be furnished by the plumber. When the peppermint test is used, two ounces of oil of peppermint must be provided for each line up to five stories and cellar in height and an additional ounce of oil of peppermint must be provided for each line when lines are more than five stories in height.

Plumbing in Tenement Houses.

175. All sections or parts of sections of the tenement house law relating to plumbing and drainage of tenement houses are to be observed, and are hereby made a part of these rules and regulations.

Gas Piping and Fixtures.

176. Hereafter the gas piping and fixtures in all new buildings and all alterations and extensions made to the gas piping or fixtures in old buildings must be done in accordance with the following rules, which are made in accordance with the provisions of section *89 of the Building Code.

For additional requirements of public buildings, theatres and places of assemblage, see Part **XXI of the Building Code.

177. Before the construction or alteration of any gas piping in any building or part of any building, a permit must be obtained from the Superintendent of Buildings. This permit will be issued only to a registered plumber. Small alterations may be made by notifying the Bureau of Buildings, using the same blank forms provided for alterations and repairs to plumbing.

178. All gas pipe shall be of the best quality wrought iron or steel and of the kind classed as standard pipe, and shall weigh according to the following scale:

**Art* 29. *New Building Code.*
***Art*. 25. *New Building Code.*

Diameters	Weights per Linear Foot
⅜ inch	0.56 pound
½ inch	0.85 pound
¾ inch	1.12 pound
1 inch	1.67 pound
1¼ inch	2.24 pounds
1½ inch	2.68 pounds
2 inch	3.61 pounds
2½ inch	5.75 pounds
3 inch	7.54 pounds
3½ inch	9.00 pounds
4 inch	10.66 pounds

No pipe allowed of less than ⅜ inch in diameter.

179. All fittings (except stop-cocks or valves) shall be of malleable iron.

180. There shall be a heavy brass straightway cock or valve on the service pipe immediately inside the front foundation wall. Iron cocks or valves are not permitted.

181. Where it is not impracticable so to do, all risers shall be left not more than five feet from front wall.

182. No pipe shall be laid so as to support any weight (except fixtures) or be subjected to any strain whatsoever. All pipe shall be properly laid and fastened to prevent becoming trapped, and shall be laid, when practicable, above timbers or beams instead of beneath them. Where running lines or branches cross beams, they must do so within thirty-six inches of the end of the beams, and in no case shall the said pipes be let into the beams more than two inches in depth. Any pipe laid in a cold or damp place shall be properly dripped, protected and painted with two coats of red lead and boiled oil or tarred.

183. No gas pipe shall be laid in cement or concrete unless the pipe or channel in which it is placed is well covered with tar.

184. All drops must be set plumb and securely fastened, each one having at least one solid strap. Drops and outlets less than ¾ of an inch in diameter shall not be left more than one inch below plastering, centrepieces or wood-work.

185. All outlets and risers shall be left capped until covered by fixtures.

186. No unions or running threads shall be permitted. Where necessary to cut out to repair leaks or make extensions, pipe shall be again put together with right and left couplings.

187. No gasfitters' cement shall be used, except in putting fixtures together.

188. All gas brackets and fixtures shall be placed so that the burners of same are not less than three feet below any ceiling or woodwork, unless the

same is properly protected by a shield, in which case the distance shall not be less than eighteen inches.

No swinging or folding gas brackets shall be placed against any stud partition or woodwork.

No gas brackets on any lath and plaster partition or woodwork shall be less than five inches in length, measured from the burner to the plaster surface or woodwork.

Gas lights placed near window curtains or any other combustible material shall be protected by a proper shield.

189. Gas outlets for burners shall not be placed under tanks, back of doors or within four feet of any meter.

190. All buildings shall be piped according to the following scale:

Diameter	Length	Burners
3/8 inch	26 feet	3
1/2 inch	36 feet	6
3/4 inch	60 feet	20
1 inch	80 feet	35
1 1/4 inch	110 feet	60
1 1/2 inch	150 feet	100
2 inch	200 feet	200
2 1/2 inch	300 feet	300
3 inch	450 feet	450
3 1/2 inch	500 feet	600
4 inch	600 feet	750

191. Outlets for gas ranges shall have a diameter not less than required for six burners, and all gas ranges and heaters shall have a straightway cock on service pipe.

192. When brass piping is used on the outside of plastering or woodwork, it shall be classed as fixtures.

193. All brass tubing used for arms and stems of fixtures shall be at least No. 18 standard gauge and full size outside so as to cut a full thread.

All threads on brass pipe shall screw in at least 5/16 of an inch. All rope or square tubing shall be brazed or soldered into fittings and distributors, or have a nipple brazed into the tubing.

194. All cast fittings, such as cocks, swing joints, double centres, nozzles, etc., shall be extra heavy brass. The plugs of all cocks must be ground to a smooth and true surface for their entire length, be free from sandholes, have less than 3/4 of an inch bearing (except in cases of special design), have two flat sides on the end for the washer, and have two nuts instead of a tail screw. All stop pins to keys or cocks shall be screwed into place.

195. After all piping is fitted and fastened and all outlets capped up, there must be applied by the plumber, in the presence of an inspector of the Bureau of Buildings, a test with air to a pressure equal to a column of mercury 6

inches in height, and the same to stand for five minutes; only mercury gauge shall be used. No piping shall be covered up, nor shall any fixture, gas heater or range be connected thereto until a card showing the approval of this test has been issued by the Superintendent of Buildings.

196. No meter will be set by any gas company until a certificate is filed with them from the Bureau of Buildings certifying that the gas pipes and fixtures comply with the foregoing rules.

Modifications.

197. When for any reason it may be impracticable to comply strictly with the foregoing rules, the Superintendent of Buildings shall have power to modify their provisions so that the spirit and substance thereof shall be complied with. Such modifications shall be indorsed upon the permit over the signature of the Superintendent of Buildings.

VALIDITY OF PLUMBING RULE

The validity of Rule 50 of the plumbing rules of the several bureaus of buildings is established in a decision by the Appellate Division, First Department, handed down in the case of City of New York v. Conrad Alheidt. The case as reported in the New York Law Journal of January 10, 1918, and is there summarized as follows:

> "Section 50 of the Plumbing Rules, which provides 'that all pipes issuing from extension or elsewhere which would otherwise open within twenty feet of the window of any building must be extended above the top of any window located within such distance is a valid provision, and should be liberally construed in the interest of the public health in order that noxious gases should not be drawn into nearby windows."
>
> "The use of the word 'adjoining' in another and distinct part of the ordinance, providing, where buildings are of different height, for the extension of vent lines along the roofs of higher buildings, does not restrict the application of such provision to buildings actually contiguous to buildings containing vent lines."

The decision would seem to carry with it also a recognition of the plumbing rules in general, so that they have in effect the same force as any city ordinance.

METHOD FOR TESTS FOR ANTI-SIPHON TRAPS OR FIXTURES.

Adopted by the Board of Standards and Appeals, February 11, 1919.

Resolved, that the following be and it hereby is adopted by the board of standards and appeals as the method prescribed for tests for anti-siphon traps or fixtures, which must be successfully passed before such traps or fixtures shall be approved under Rule 88, Rules for Plumbing and Drainage:

Instructions.

1. The entire cost and responsibility for the installation of the necessary equipment for such test shall be borne by the person or firm submitting the appliance.

2. Such person or firm shall also furnish the board, together with the application for test, the following material and information:

(a) A stock trap of the size and design to be tested which shall be of the P and S type and shall be of lead or brass, cast in one piece, and without interior partitions or mechanism.

(b) A similar trap cut in half.

(c) A similar trap, to be used in the test, provided with glass observation ports of sufficient size to permit clear observation of the action occurring within the trap during test, and such observation ports shall be so located that the amount of water seal remaining after each test can be readily observed.

(d) An affidavit that the three traps submitted are regular stock traps.

(e) A list of all cities, towns or municipalities where such trap has been officially approved for use without back venting.

The testing apparatus shall be located within the City of New York, and in a place, building or structure to meet the approval of the testing authorities Such apparatus shall be so located that every part is easily accessible for inspection.

Apparatus.

The apparatus shall consist of the following:

A tank of not less than fifty nor more than one hundred and fifty gallons capacity, with adequate water supply for refilling the same during the test.

A vertical wrought iron or steel pipe line fifty feet long, connected to the underside of the tank, and of the same internal diameter as the trap to be tested.

A quick-opening valve, located ten feet below the underside of the tank.

A TY fitting located two feet below the quick-opening valve, with horizontal branch pipe connected thereto, of the same diameter as the vertical lines, this branch line not to exceed two feet in length, with a pitch towards the vertical line of two inches to the foot, and the trap to be tested shall be connected to this horizontal branch pipe.

A wash basin, or fixture answering the same purpose, which can be conveniently connected or disconnected from the inlet side of the trap.

The test shall be conducted as follows:

For Anti-Siphon Qualities.

For the purpose of determining the efficiency of the trap, the tank shall be completely filled, a water seal established in the trap; and:—

The quick-opening valve shall be opened for five seconds, then closed for five seconds, and this alternating process repeated five times.

The quick-opening valve shall be opened and the entire contents of the tank discharged at one time..

The wash basin shall be connected to the trap, filled with water, and both wash basin and tank discharged simultaneously. The quick-opening valve shall be kept open until the entire contents of the tank has been discharged.

The trap shall be disconnected and a bridge of solid soap formed across the lower half of the discharge end of the trap, so as to effectually block one-half of the clear water-way, and the foregoing tests repeated.

Each operation shall be repeated several times, if desired by the testing authorities.

For Self-Cleansing Qualities.

For the purpose of determining its self-cleansing qualities, the trap shall be filled with sand and the wash basin filled with water and allowed to discharge. A similar operation shall be repeated with tea leaves, coffee grounds, sawdust and grated soap.

For Service Qualities.

The service qualities of the trap may be tested as follows:

A trap which has been in actual constant use for a period of not less than one year shall be removed under the supervision of a representative of the testing authorities, split into two halves, and submitted for inspection, for the purpose of determining whether sediment or coating of grease or other foreign matter has accumulated in the trap during service conditions.

Approval.

An approval shall not be issued for any anti-siphon trap which has been subjected to the foregoing tests unless the trap has:

1. Maintained its water seal throughout the test.

2. Been successfully scoured of any foreign substance placed in the trap, when water has been discharged through same.

3. Upon inspection, after service, shown no excessive accumulation of grease or other foreign substance.

Deep Seal Siphon-Jet Fixtures, or Anti-Siphon Fixtures.

Instructions: Applicants for approval of deep seal siphon-jet or anti-siphon fixtures shall submit the following with their application:—

(a) A stock fixture of the size and design to be tested.

(b) A similar fixture, cut in half.

(c) A similar fixture, to be used in the test, provided with glass observation ports of sufficient size to permit clear observation of the action occurring within the fixture during test, and such observation ports shall be so located that the amount of water seal remaining after each test can be readily observed.

(d) An affidavit that the three fixtures submitted are regular stock fixtures.

Apparatus.

The apparatus shall be similar to that required for anti-siphon traps, except that vertical and horizontal pipes shall have an internal diameter of three inches for testing slop sinks and four inches for testing water closets; tank

shall have a capacity of not less than one hundred gallons and the fixture shall be provided with its usual water supply so that same may be flushed when required.

Test.

For the purpose of determining the efficiency of the fixture to maintain a water seal, it shall be tested in a manner similar to that prescribed for anti-siphon traps, except that no soap bridge need be provided at the outlet.

William E. Walsh, *Chairman.*

William J. O'Gorman, Secretary.

CHAPTER 131

Examination Rules

EXAMINING
BOARD OF
PLUMBERS
CITY OF NEW YORK

1925

RULES

I.

Persons applying for examination for certificates to engage in the business of master or employing plumber shall, before being examined, file with the Board an application on such forms as may be prescribed by the Board, and shall furnish to the Board such information as it may require concerning the applicant's fitness and qualifications to receive a certificate as aforesaid. All applications must be under oath.

Each applicant shall be required to furnish two vouchers, who shall appear before the Board and sign under oath on forms prescribed by the Board certifying to the time the applicant has been employed by them as journeyman plumber. Such vouchers at the time of signing applications must be lawfully engaged in the plumbing business in the City of New York.

The Board shall refuse to receive an application from any person who at the time of making application may be unlawfully engaged in business as a master or employing plumber.

Each applicant at the time of making his application shall be required to present his photograph, the size of such photograph not to exceed 2½ inches square, and to bear on its reverse side the name and address of the applicant.

II.

No person shall be examined unless he shall have had an experience of at least five years as a journeyman plumber, and is able to furnish satisfactory evidence of such fact.

No application will be received from any person who is not a citizen of the United States.

III.

The examinations of the Board shall be in two parts, namely, a practical test to determine the applicants skill as a journeyman, and a written examination. The written examination shall consist of questions and plan to determine the applicant's fitness and qualifications to engage in the business of master or employing plumber.

IV.

All examinations shall be written by the applicant and must be in English.

V.

The time and place of holding examinations shall be left to the discretion of the Board. Ample notice shall be given to applicants.

VI.

Persons who pass the tests as prescribed by the

Board shall be eligible to receive a certificate of competency as master or employing plumber.

VII.

An applicant who fails in the practical test shall not be eligible for another test until the expiration of three months; should he fail in the second test he will not be eligible for a third test until the expiration of six months, and, failing in the third test, he will not be eligible for a fourth test until the expiration of one year. An applicant who fails in the written examination shall not be eligible for re-examination until the expiration of one month; should he fail in the second examination he will not be eligible for another examination until the expiration of three months; should he fail in the third examination he will not be eligible for another examination until the expiration of six months, and should he fail in the fourth examination he will not be eligible for another examination until the expiration of one year.

VIII.

All applications will expire and be cancelled after a period of one year if the applicant does not appear for examination within that period.

IX.

Before issuing a certificate to engage in the business of master or employing plumber the Board shall inquire into the applicant's fitness and qualifications for conducting such business, and may require the applicant to submit under oath such evidence, in addition to the examinations and tests hereinbefore provided, as will satisfy the Board that he is a person of good repute, character and responsibility, and otherwise qualified to engage in business as a master or employing plumber.

X.

Each applicant for examination shall pay the sum of Five Dollars, and the further sum of Five Dollars, upon the issuance of a certificate to engage in the business of master or employing plumber. Where an applicant has paid the first Five Dollars for examination and failed, for each subsequent examination he shall pay an amount to be fixed by the Board, not to exceed Five Dollars.

XI.

In case a certificate of competency is lost by the holder thereof, the Board may issue a duplicate where such original certificate was issued during the term of office of all the members of the Board in office when such duplicate certificate is requested. The charge for such duplicate certificate shall be Five Dollars. In other cases the Board shall issue a certificate of record stating that the records of the office show that a certificate was issued to a specific person. The charge for such certificate of record shall be Two Dollars.

XII.

Applicants who pass the examination of the Board and receive certificates of competency will be required, upon engaging in business, under the provisions of chapter 305 of the Laws of 1916, to obtain a metal plate or sign, the fee for which is Five Dollars.

XIII.

Any person retiring from business as a master or employing plumber shall surrender to the Examining Board of Plumbers his metal plate or sign. His failure to do so will constitute a misdemeanor, and he will be prosecuted to the full extent of the law, as provided in chapter 305 of the Laws of 1916.

XIV

The Board shall reserve the right to refuse to issue a metal sign for a branch shop until it has been proven to the satisfaction of the Board that such branch shop is absolutely necessary.

XV.

The Board shall reserve the right to refuse to issue a metal sign to any person whose name is not exposed to the public on the window of his place of business.

XVI.

Where the Board issues a metal sign such metal sign shall not be transferred to another location without first notifying the Board.

XVII.

Where the Board issues a metal sign such metal sign shall not be transferred to any co-partnership or to any corporation of which the holder of such metal sign may later become a partner or an officer, until he has notified the Board.

NOTICE TO APPLICANTS

The Board will receive applicants with their vouchers on the first Tuesday of the month between the hours of 2 and 4 o'clock P.M.

Persons who cannot read and write English will not be permitted to make application.

Applicants of foreign birth must present their own or their parent's naturalization papers.

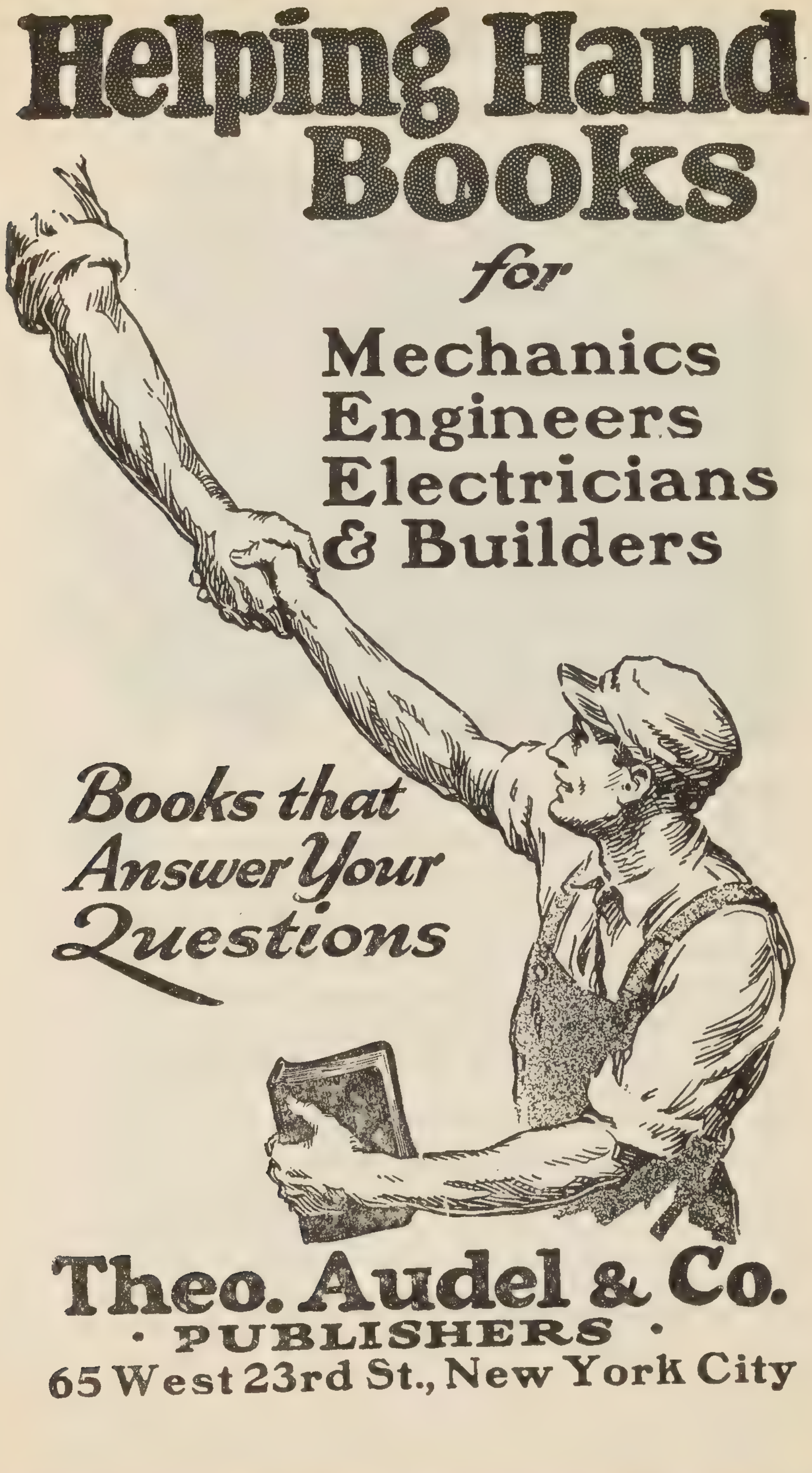
Both vouchers will be required to present their cards of registration of the current year at time of signing application.

We have a Commissioner of Deeds at the office who will take the affidavits of applicants and their vouchers. There will be no charge for this service.

It is a violation of law, punishable by fine or imprisonment, to open a shop or to display a sign before a certificate of competency has been obtained.

EXAMINING BOARD OF PLUMBERS.

22-2006-24-D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—How to construct built-up sills.
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—How to allow for variation of joists.
—How to construct a well hole.
—How to frame a studding.
—How to frame corner posts.
—How to lay out and cut braces.
—How to attach lath to corner posts.
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